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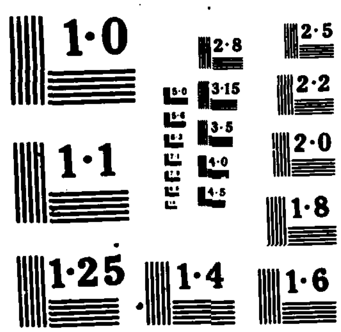

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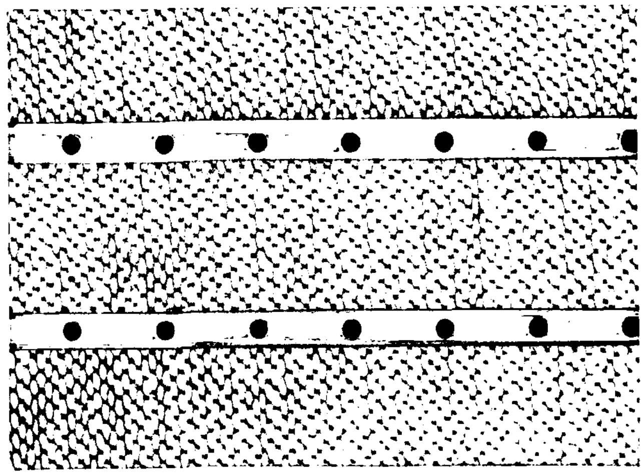

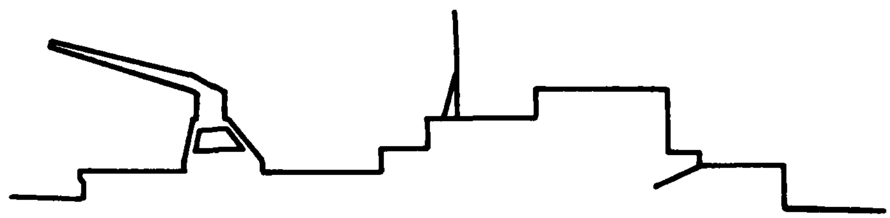

Ocean Engineering

CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON NAVY YARD
WASHINGTON, DC 20374

(2)

PRELIMINARY ANALYSIS OF SOAR CABLE LANDING SITES AT SAN CLEMENTE ISLAND

by

William N. Seelig

FPO-1-84(13)

May 1984

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The SOAR permanent underwater range is now in the preliminary design stage for an area west of San Clemente Island, California. The purposes of this report are to: (1) summarize environmental data available for the area around the island, (2) identify and analyze potentially useful cable landing sites (Con't)

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using available data and (3) recommend promising methods of landing the cables at the various sites.

Four sites were examined and the sites are ranked from best to worst as: Seal Cove, West Cove, Eel Point and North Wilson Coe. The ranking process considered wave climate, wave forces on the cables, local hydrography and topography, construction conditions, the offshore profiles, track and the distance from the site to the range. Two passes of armor are required to protect the cables. Tentative lengths of this armoring are recommended. Detailed sub-bottom and hydrographic studies need to be performed at Seal Cove and West Cove to determine if 3 feet or more of sand is available offshore in water depths greater than 75 feet. If so, the amount of armor required could be reduced and significant cost savings could result. A swim-by of Eel Point is recommended to determine if this site warrants further consideration. The cable landing area in Seal Cover should be examined to determine if there are any special problems with this area. It is also recommended that the surf and runup conditions in Seal and West Coves be examined during a major storm to determine if there are any unusual hydraulic conditions present.

PRELIMINARY ANALYSIS OF SOAR CABLE LANDING SITES
AT SAN CLEMENTE ISLAND, CALIFORNIA

BY
William N. Seelig

EXECUTIVE SUMMARY

The SOAR permanent underwater range is now in the preliminary design stage for an area west of San Clemente Island, ~~California~~. The purposes of this report are to: (1) summarize environmental data available for the area around the island, (2) identify and analyze potentially useful cable landing sites using available data; and (3) recommend promising methods of landing the cables at the various sites. 4 sites examined-

Four sites were examined (Figure 1) and the sites are ranked from best to worst as: Seal Cove, West Cove, Eel Point and North Wilson Cove. The ranking process considered wave climate, wave forces on the cables, local hydrography and topography, construction conditions, the offshore profiles, track and the distance from the site to the range. Two passes of armor are required to protect the cables. Tentative lengths of this armoring are recommended. Detailed sub-bottom and hydrographic studies need to be performed at Seal Cove and West Cove to determine if 3 feet or more of sand is available offshore in water depths greater than 75 feet. If so, the amount of armor required could be reduced and significant cost savings could result. A swim-by of Eel Point is recommended to determine if this site warrants further consideration. The cable landing area in Seal Cove should be examined to determine if there are any special problems with this area. ~~It is also recommended that the~~ surf and runup conditions in Seal and West Coves should be examined during a major storm to determine if ~~there are~~ any unusual hydraulic conditions present.

(Southern California Acoustic Array),

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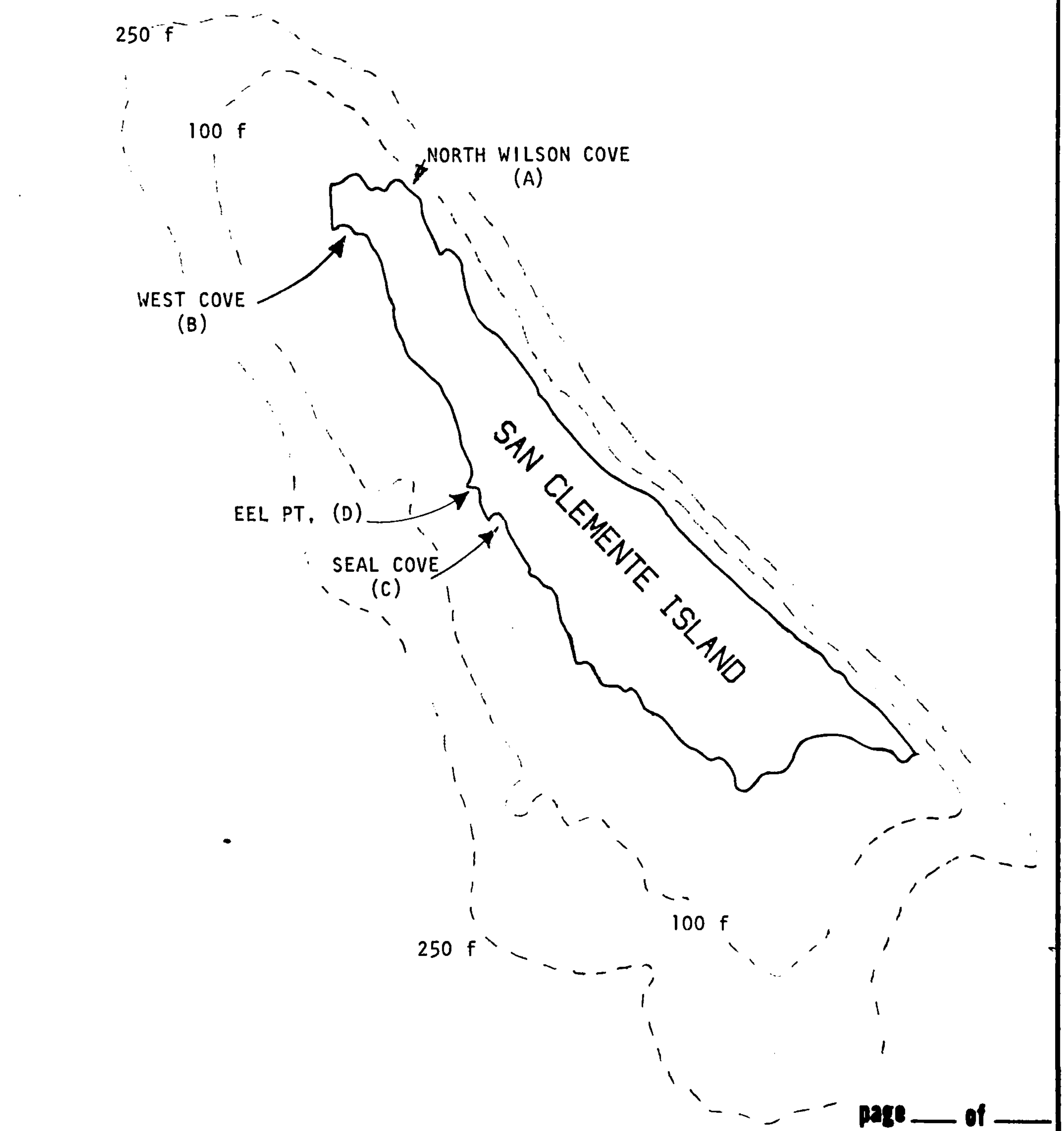

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PRELIMINARY ANALYSIS OF SOAR CABLE LANDING SITES AT SAN CLEMENTE ISLAND, CALIFORNIA

by

William N. Seelig

INTRODUCTION

A permanent underwater range, "SOAR", is being considered for the area west of San Clemente Island (Figure 2). It is now envisioned that the initial portion of this range of 22 cables (see dashed line on Figure 2) would be installed first in FY 87 and the complete range finished later in the next decade. The next addition could add up to 48 more cables, carrying power and data, running from the range to San Clemente Island.

PURPOSE

The purposes of this report are to: (1) summarize available environmental data for the island that will be useful in designing the cable landing sites, (2) identify and analyze potentially useful cable landing sites and (3) recommend promising methods of landing the cables at the various sites.

CABLE CHARACTERISTICS

Table 1 presents a list of the various cables that were used in the analysis of the various sites. The SSL cables were found to be typical of the other cables, therefore these results are emphasized in this report.

GENERAL CABLE LOCATION SELECTION CRITERIA

As a general rule, cables should be located to minimize the total life cycle cost including: material cost, installation cost, cost of repair and/or replacement and costs associated with down time if a cable is damaged. This report only considers physical factors of cable location. Cost analyses will have to be performed as more data become available and various alternative methods are determined.

Water motions due to waves have proven to be especially damaging to cables located in the Pacific (for example, Barking Sands, Hawaii, which has a similar wave climate) because high, long period waves occur persistently. The resulting reversing currents produced by the waves cause abrasion to the cables and can move typical cables on rock in relatively deep water. Therefore, the ideal places to locate cables are:

(1) In an area not exposed to the waves, such as in a cove or sheltered portion of the island.

(2) In an area where the water gets deep quickly, so that the influence of the waves rapidly diminishes.

(3) In an area with an adequate layer of sediment, so the cable can be buried and stay buried. However, maintance is a problem with a buried cable.

(4) In a naturally occurring trench, especially a trench filled with sediment. Wave induced currents are generally much smaller in such depressions than at adjacent areas.

(5) In an area where the cable is parallel to wave induced currents to minimize the forces on the cable.

WAVE CLIMATE OF SAN CLEMENTE ISLAND

Waves may damage cables due to abrasion or breakage during extreme events. Waves may also pose a hazard during installation and cable repair. Therefore, understanding the wave climate will aid in selecting promising

sites and planning field operations. Two published sources of data provide useful wave information for Western San Clemente Island. Reference (2) contains statistics of waves measured in 1983 by a buoy at Begg Rock (West of San Niclols Island) in a water depth of 360 feet (See figure 2). Reference (3) summarizes shipboard observations of waves made throughout the southern California region. In addition, References 4, 5 and 6 were used to hindcast wave data for the eastern side of San Clemente Island. Based on these data the 50 year design waves for this area are taken as:

	Western Side	Eastern Side
Significant wave height	34 feet	11.2 feet
Wave period	14.5 seconds	8.6 seconds
Wave direction	WSW	SE

Analysis of these data show that "wave activity" (wave power normalized by probability) occurs primarily from the northwest quadrant with additional wave activity from the west and southwest (Figure 3 a). "Wave activity" is a single parameter defined as:

wave activity = Hs Tp P (Figure 3a)

where Hs = significant wave height

Tp = period of peak energy

P = probability

that indicates the amount of damaging exposure that any open coast structure would experience due to the waves.

Further analysis of the data shows that the largest waves come from the WSW or W directions (Figure 3 b). The smallest waves come from the northeast directions because all waves on the eastern side of the island are fetch limited.

Recorded wave data from 1983 shows that the smallest waves occur on the western side of San Clemente Island during August and September. In addition, only one major storm produced high waves during October. The largest waves occur during November and December (Figure 4). If this one year of data is representative, August and September would be the best months to conduct installation or repair operations.

WAVE INDUCED WATER PARTICLE MOTIONS

When a wave passes a point the orbital motions of the water particles produce a reversing current. The highest velocity, Umax, occurs on the bottom as the wave crest passes. This current velocity then quickly drops off and reverses as the wave trough passes the point. The cycle is then repeated during the passage of the next wave.

Water motion statistics were estimated at various water depths using the significant wave height, Hs, using the data from Reference (2) and the analysis techniques given in Reference (6). Figure (5) presents the estimated hours per year that various maximum water particle velocities are exceeded at a given value of depth. Some of these statistics are also given in Table 2. For example, at a water depth of 60 feet, waves on western San Clemente Island during 1983 were estimated to produce a Umax greater than or equal to 3 feet/second for 990 hours. The hours per year and peak velocity can be seen to quickly drop off as the water gets deeper than 60 feet, so that at a depth of 120 feet velocities were always less than 5 feet/second. The peak values of velocity predicted for 1983 can be seen to be about the same (8 to 8.5 feet/second) for all water depths less than 60 feet. At depths greater than 60 feet the maximum velocities drop off from 8 ft/sec at 60 feet to 4.8 ft/sec at a depth of 120 feet (Figure 5).

Wave induced water particle motions due to the design waves are shown for various locations around the island in Figure 6. North Wilson Cove (Site A) has the lowest velocities for a given depth with the three sites on the western side of the island all having much higher velocities (Sites B, C and D). At all of the western sites, Umax is greater than 10 feet/second for water depths between 15 and 70 feet deep for the 50 year event. Therefore, exposure to these water depths should be minimized as much as possible when locating cables or structures on the bottom.

If a cable is resting on rock and becomes exposed to wave currents the cable may then move. If the cable moves it will abrade and may break. Therefore prudent design practice implies that an unstable cable should be armored to improve stability, tied down (Reference 1), or buried to prevent exposure to the waves. The stability of a cable is a highly complex function of water depth, wave height, wave period, deepwater wave angle, cable orientation, cable diameter and cable weight. Reference (1) presents methods of calculating cable stability and Appendix B presents typical calculations for the case of cables running perpendicular to an idealized profile of parallel contours.

Preliminary calculations show that <u>if inadequate sediment is available to bury cables</u>, then unarmored cable can only be used in water depths greater than 430 feet (Appendix B). Two passes of armor or split pipe can be used to improve stability and abrasion resistance (Reference 1) but these may require some further stabilization depending on local conditions (Appendix B).

PREDICTED AMOUNTS OF SAND LEVEL CHANGE

Waves can move significant amounts of sediment and expose buried cables, in cases where inadequate sediment cover is present. The thicknesses of sediments offshore at San Clemente are unknown, but charts and preliminary surveys indicate sand is present in some areas. Calculations using the techniques in Reference (9) show that less than one foot of sand level change would be expected for water depths greater than 41 feet for each year on western San Clemente Island (Appendix C). A 50 year event would produce less than one foot of sand level change in water depths greater than 73 feet. A 30 year design event would produce 13 feet of sand level change in 20 to 30 feet of water (Reference 8, if there is that much sand present) and gradually less change out to about 60 feet of water. The thickness and type of sediment at proposed cable sites needs to be measured to determine if cables can be safely buried.

PROMISING SOAR CABLE LANDING SITES

All available information was examined and four sites selected as possible sites for SOAR cable landings. These sites are:

(A) North Wilson Cove

(B) West Cove

(C) Seal Cove

(D) Eel Point

as shown on Figure 7. Offshore profiles for each site are presented in Figure 8. A description of each site and the pros and cons of each location is given below.

(A) North Wilson Cove

At West Cove the water depth drops off rapidly, it is easily accessible for construction, the site is beyond anchorage areas and is outside of the nearby Seal demolition training areas in Northwest Harbor. The site is completely sheltered from the damaging wave activity from the northwest and wave induced water particle velocities are greater than 5 feet per second in only 12 feet or less of water for the 50 year event (Figure 6). Two passes of armor would be needed for cables at this site out to a depth of 150 feet of water (about 950 feet offshore) based on an analysis using methods in Reference (1). Some additional tie down may be necessary for the portion of the cables in less than 60 feet of water (if no sediment for burial is present) because the short period waves in the area produce currents at large angles to the cables. Therefore cables with even two passes of armor are unstable. The exact amount of armor and stabilization can only be determined after a more detailed site survey is made.

Unfortunately, cables at this site must be several miles longer than for other sites. It is recommended that the cable be run perpendicular to contours until it is outside the 100 fathom depth contour to be sure that waves have minimal affect on the cables. Beyond this depth the cable track can take the shortest routes to the range.

(B) West Cove

West Cove has been selected as the site for landing two interim cables to be installed in FY84. These cables are designed to act only as a temporary source of power and data for a preliminary range.

This site is protected from the damaging NW waves and an unknown thickness of sand/sediment is present on the proposed cable route (Figure 9, References 7 and 8) and may protect the cables from the waves. West Cove is highly accessible from land and sheltered from any waves produced by winds from the east. However, the sediment thickness is unknown and the shelf in the area is flat (Figure 8) so 17,000 feet of two passes of armor are required if rock is present (Reference 8). This armor is necessary because unarmored cable resting on rock will become unstable for water depths less than 450 feet (Figure 10). Design waves from the WSW will move directly into this cove and may produce large changes in the sand level. Large long period waves will also produce high wave runup on the beach (Appendix C) and should be able to easily move the cobbles and boulders on the upper portion of the beach.

(C) Seal Cove

Seal Cove (Figures 7 and 11) has the advantage that the water depth drops off to over 60 feet within the cove, so the surf zone would be small in lateral extent. The cables could be run up an indentation to the north of the cove and thereby be almost totally sheltered from waves breaking at the shoreline (Figure 11). The water depth further offshore drops off rather quickly (Figures 8 and 12) and sand is shown as the bottom material (Figure 11), so the cables could possibly be buried. If adequate sand is not available, approximately 7800 feet of cable would have to be protected with two passes of armor (see Appendix B). Some cable tie down may also be necessary.

Note that a disadvantage of this site is the steep slope of the terrain in the area. A road comes down to the point at Seal Cove, but there may be a 100 foot drop off between the road and water line according to the USGS map of the area. Local conditions in this area need to be investigated. It would also be useful to observe conditions in Seal Cove during the winter months to determine the wave heights and runup in the cove.

(D) Eel Point

This unique site consists of a submerged point with a water depth of about 30 feet and length of 3000 to 3200 feet (Figures 11 and 13). Beyond the point the water drops off very rapidly into a natural trench. Refraction diagrams suggest that the design waves would break throughout the submerged point and that smaller waves will be focused and break toward the landward end of the submerged point (Figure 14). Conditions at this site are expected to be highly turbulent during all but August and September.

Cables at Eel Point would either have to be trenched and grouted out to a depth of 60 feet or suspended on towers. At least 6 large towers would be required. Cables would then have to have two layers of armor out to a depth of 450 feet (for about 2200 feet). The slope in the canyon may be as steep as 1 on 1 with sharp rock outcrops, so additional cable protection could also be necessary. A detailed site survey needs to be performed to confirm constructability.

SUMMARY AND CONCLUSIONS

Four sites have been used in a preliminary analysis of SOAR cable landing sites using available data. Seal Cove and West Cove seem to be the best sites when the following factors are considered: wave climate, wave forces on the cables, local hydrography and topography, construction conditions, the local profile shape and the distance from the site to the range. Eel Point can only be seriously considered if an economical method can be used to protect the cables and assure that little maintainance is required. North Wilson Cove would require cables much longer than at the other sites.

Further field surveys of Seal Cove and West Cove are recommended with special emphasis on determining hydrography and the thickness/types of sediment available for cable burial. A swim-by should be made of Eel Point to determine if this area warrants further study. The detailed geometry of Seal Cove should be examined to determine if good working conditions are present onshore. It would also be wise to observe surf conditions at West Cove and Seal Cove during major storm conditions. The environmental data should be collected over at least a one year period to observe the seasonal variation of sediment thickness and surf conditions.

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TABLE 1: CABLE CHARACTERISTICS

Type	Armor	Dia. inches/ft.	Weight per foot	Density lbs/ft^3
SSL	Bare	0.66 0.055	0.1557	65.5
Cable	First Pass	1.058 0.08817	0.9128	149.5
Spec.	Second Pass	1.482 0.1235	2.4804	207.
(Ess)	Third Pass	2.055 0.17125	5.0804	220.6
UQC	Bare	0.988 0.08233	0.4647	87.3
Cable	First Pass First Lay	1.267 0.10558	1.1236	128.3
Spec.	First Pass Second Lay	1.527 0.12725	2.1057	165.6
(Ess)	Second Pass	2.167 0.18058	5.2171	203.7
SB	Type A	1.83 0.1525	2.805	153.6
	Type B	1.43 0.1192	1.4026	125.7
	Type D	1.25 0.1042	0.6211	72.8

TABLE 2 : PREDICTED WAVE PARTICLE MOTION STATISTICS

WEST SAN CLEMENTE ISLAND

HOURS/YR $U_{max} \geq$ GIVEN VALUE *

WATER DEPTH (FT)	30'	60'	120'	240'
VELOCITY (FT/S)				
2	4800	2200	660	40
3	2900	990	140	-
4	1850	410	15	-
5	1130	150	-	-

* Based on 1983 wave data for the open coast

Reference 2

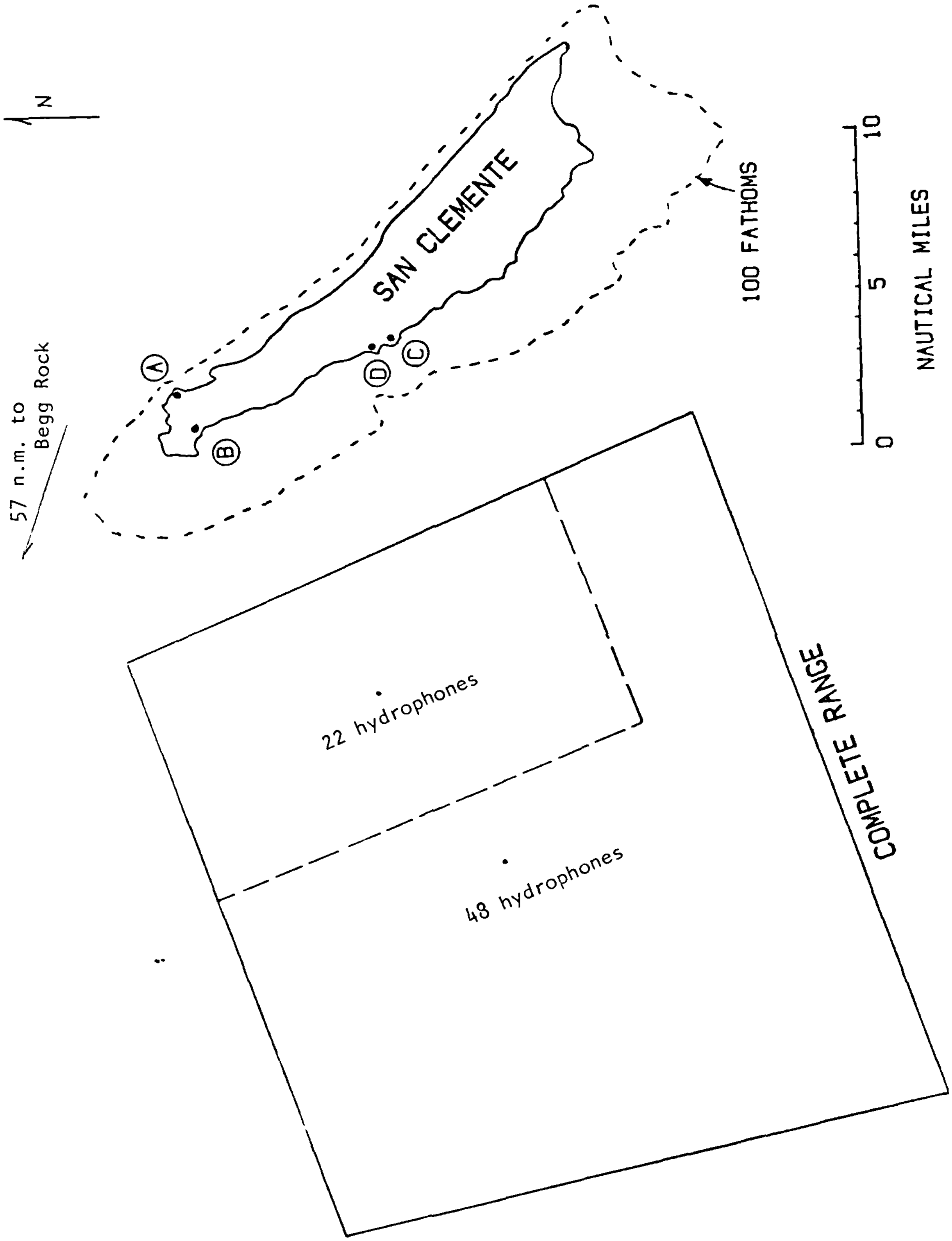
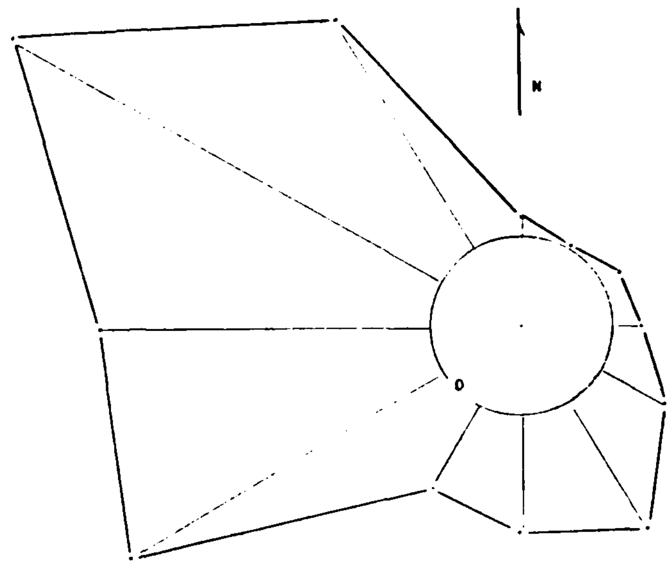


FIGURE 2. PROPOSED RANGE CONFIGURATION

CHESAPEAKE DIVISION	PROJECT:
Naval Facilities Engineering Command NDW	Station:
DISCIPLINE	E S R: Contract:
Calcs made by: date:	Calculations for:
Calcs ck'd by: date:	

(a)

WAVE ACTIVITY ROSE FOR
SAN CLEMENTE ISLAND



(b)

HOURS PER YEAR THAT
$H_s > 20$ FEET

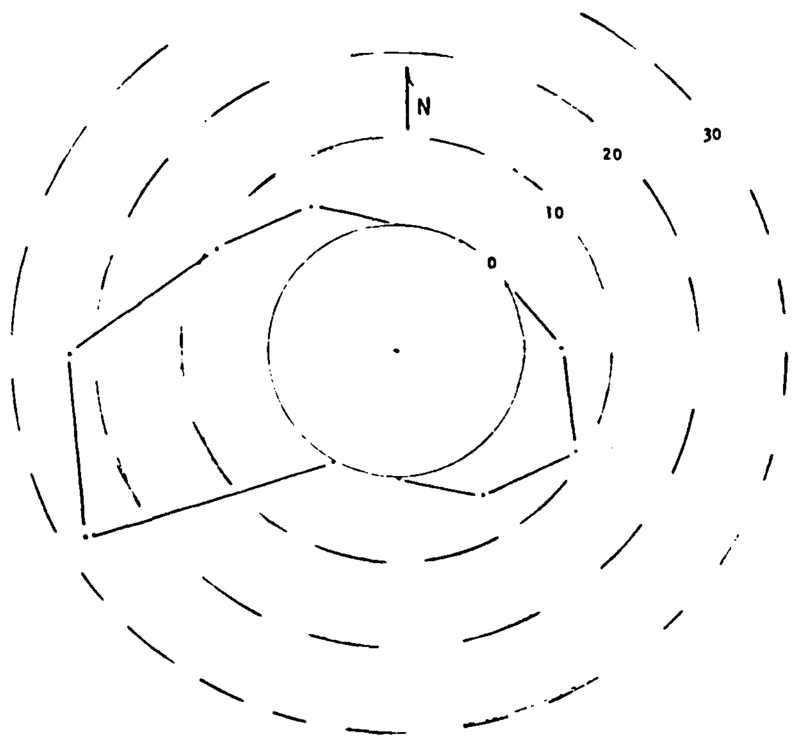


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FIGURE 3. WAVE CLIMATE FOR SAN CLEMENTE ISLAND

CHESAPEAKE DIVISION **Naval Facilities Engineering Command NDW** **DISCIPLINE**	**PROJECT:** ________ **Station:** ________ **E S R:** ________ **Contract:** ________
Calcs made by: W. Seelig **date:** 5/16/84 **Calcs ck'd by:** ________ **date:** ________	**Calculations for:** H_s at Begg Rock (d=360 ft)

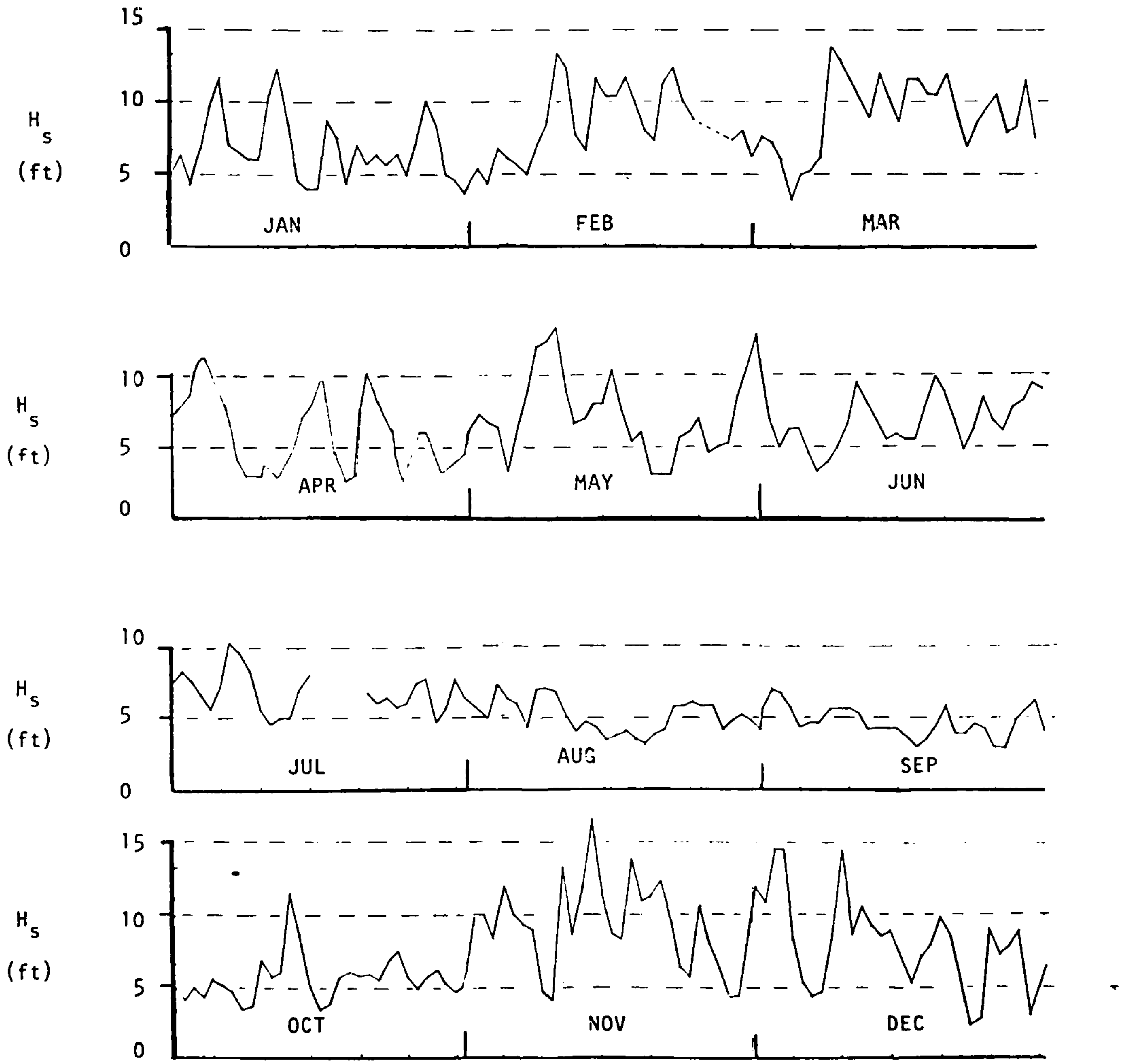

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FIGURE 4. SIGNIFICANT WAVE HEIGHT AT BEGG ROCK FOR 1983

CHESAPEAKE DIVISION **Naval Facilities Engineering Command NDW** **DISCIPLINE**	**PROJECT:** SAR **Station:** WEST SAN CLEMENTE IS. **E S R:** ______ **Contract:** ______
Calcs made by: W. SEELIG **date:** 5/18/84 **Calcs ck'd by:** ______ **date:** ______	**Calculations for:** STATISTICS OF BOTTOM WATER ~~VELOCITIES DUE TO WAVES~~

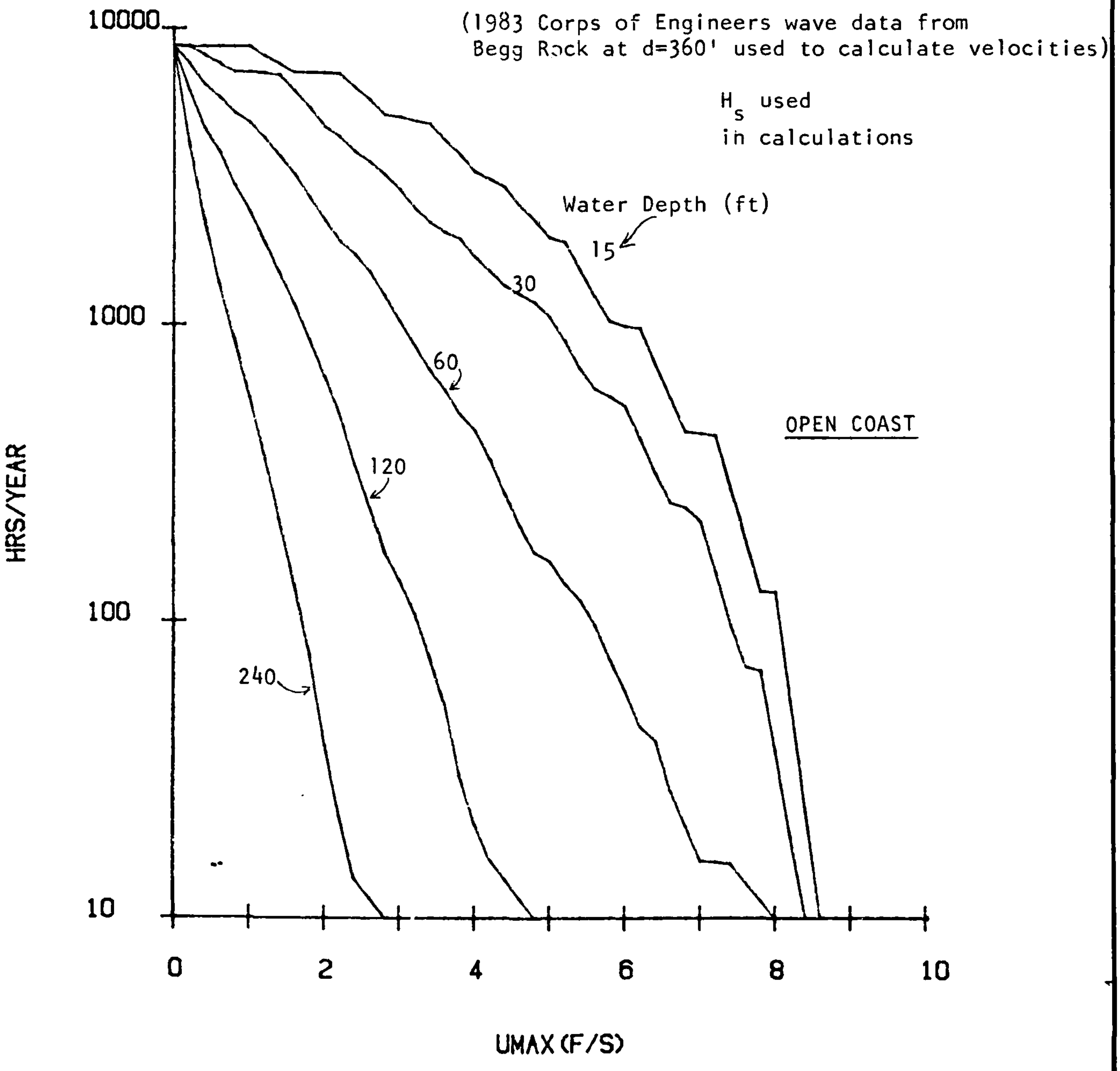

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FIGURE 5. PREDICTED WAVE PARTICLE MOTION STATISTICS FOR WESTERN SAN CLEMENTE

CHESAPEAKE DIVISION	**PROJECT:** SAR
Naval Facilities Engineering Command NDW	**Station:** SAN CLEMENTE
DISCIPLINE	**E S R:** ______ **Contract:** ______
Calcs made by: W. SEELIG **date:** 5/14/84	**Calculations for:** U_{max} as a function of Water Depth for Selected Sites
Calcs ck'd by: ______ **date:** ______	

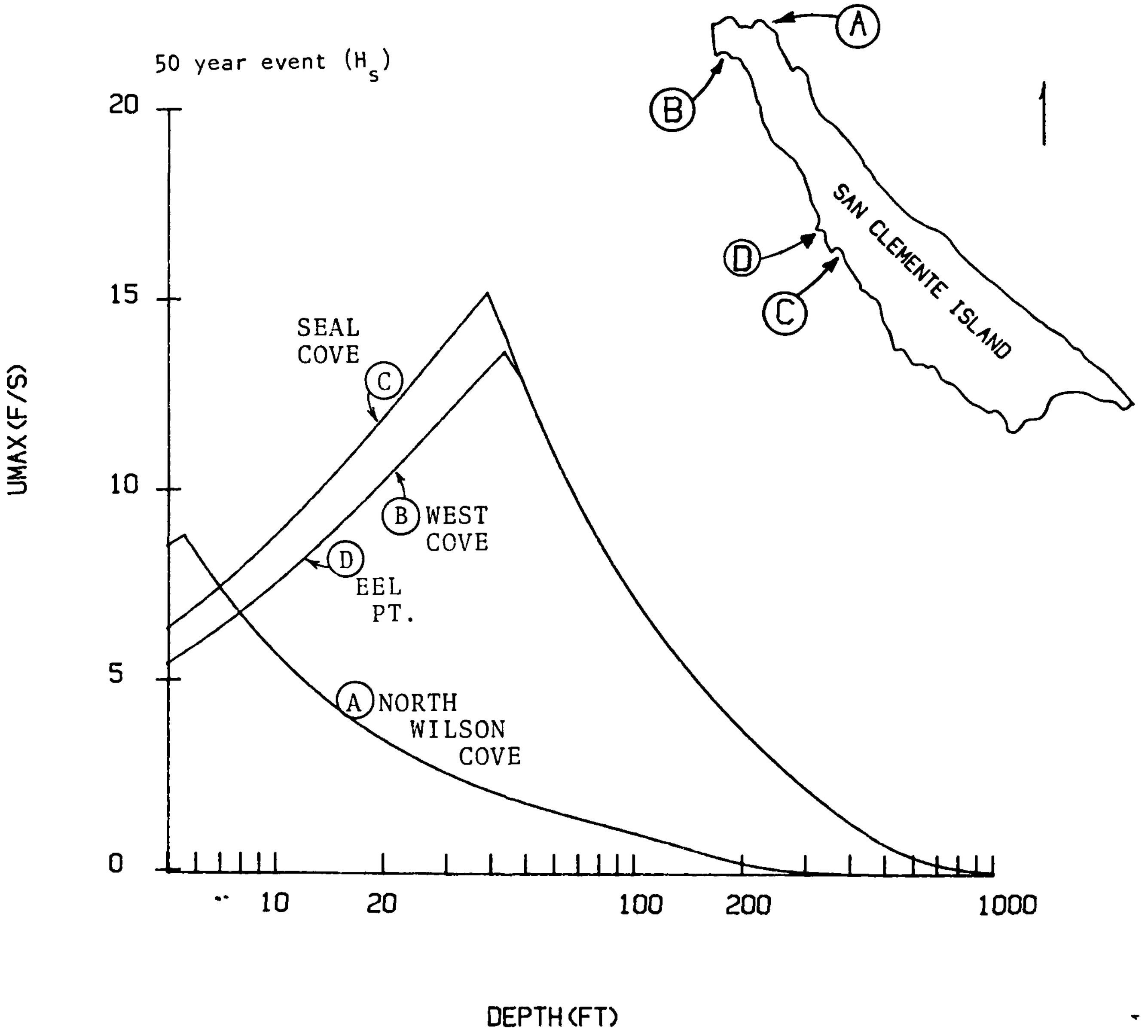

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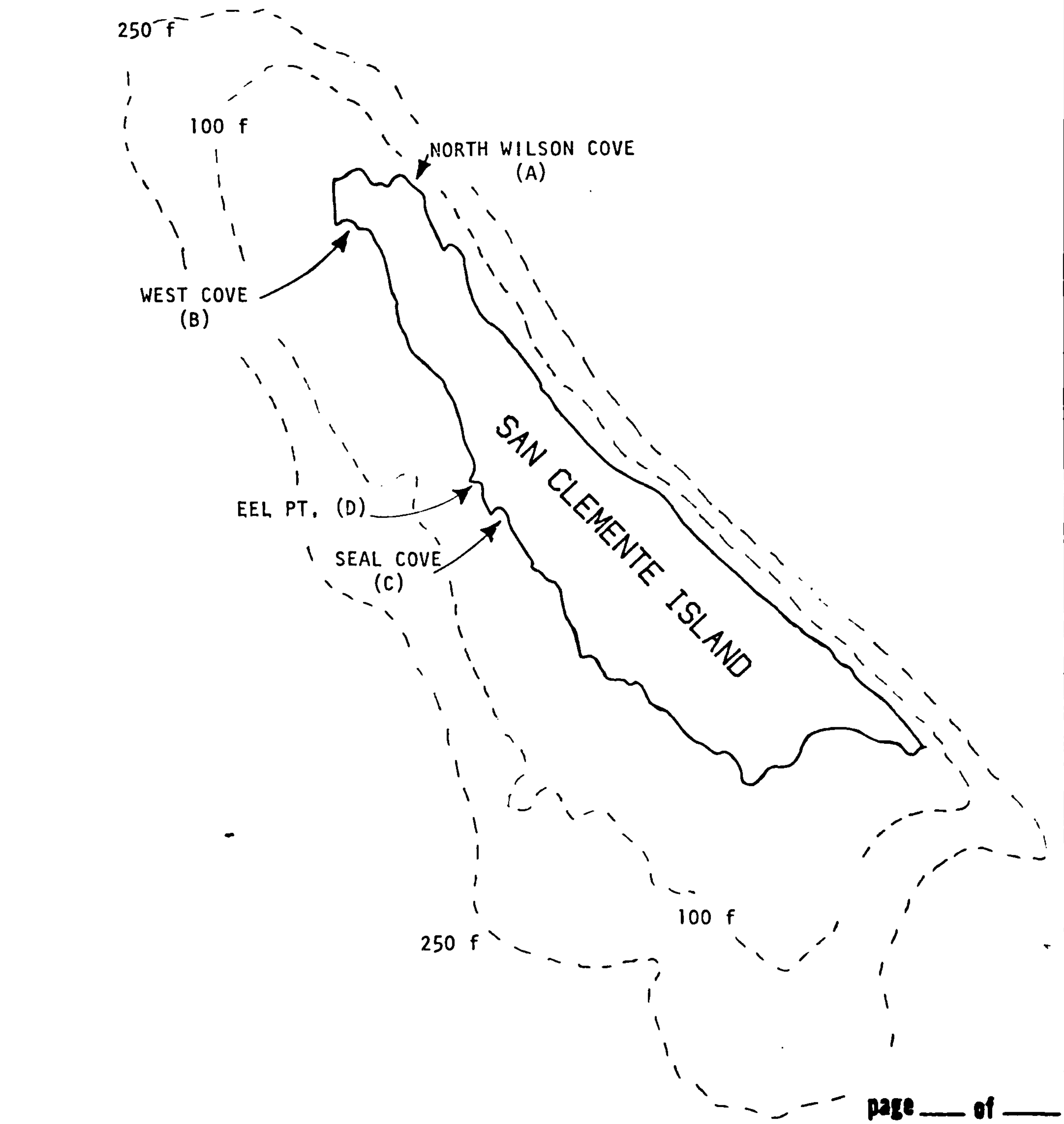
FIGURE 6. PREDICTED DESIGN WAVE PARTICLE MOTIONS

GPO 885-683

CHESAPEAKE DIVISION	PROJECT:
Naval Facilities Engineering Command NDW	Station:
DISCIPLINE	E S R: Contract:
Calcs made by: date:	Calculations for:
Calcs ck'd by: date:	



page ___ of ___

FIGURE 7. SAN CLEMENTE ISLAND

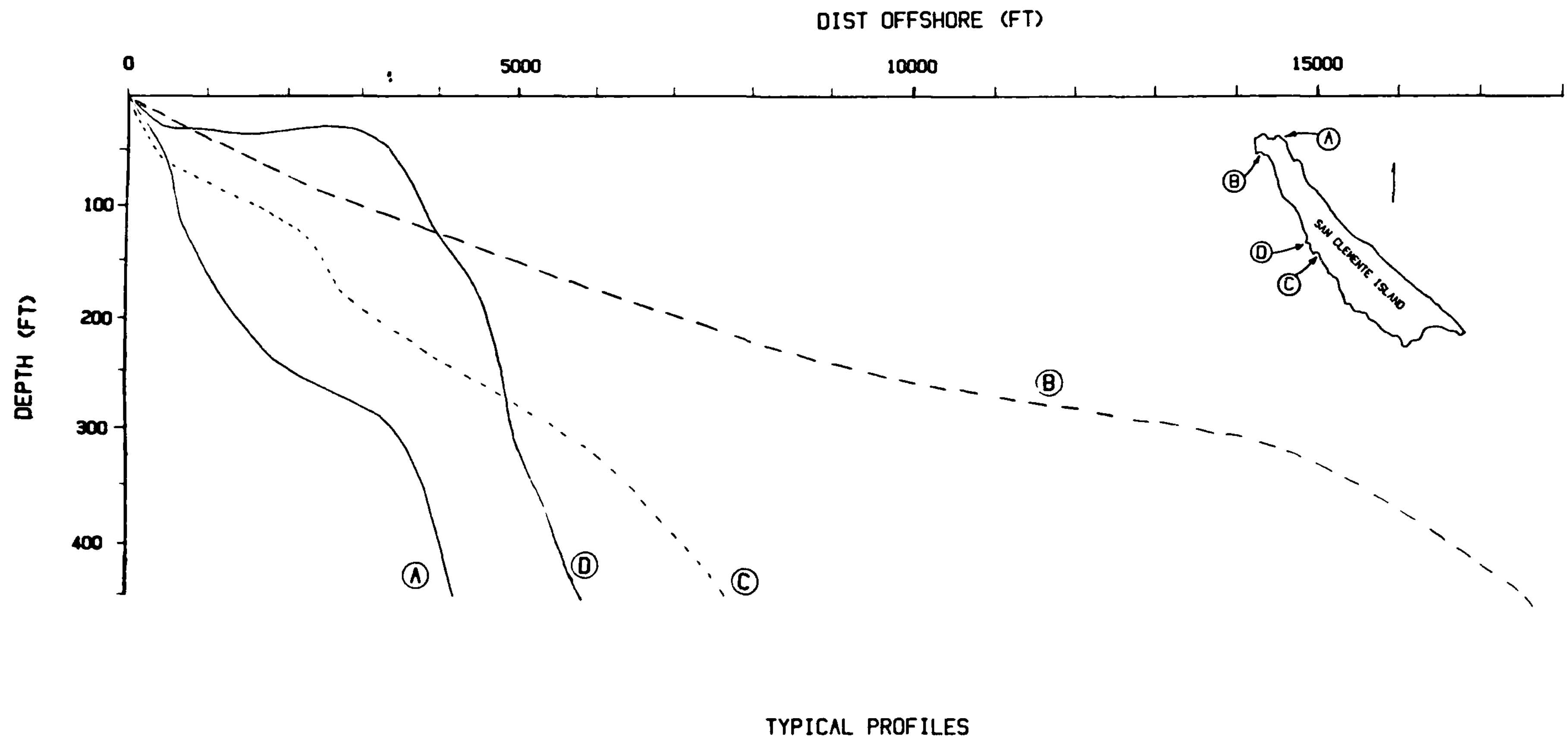


FIGURE 8. OFFSHORE PROFILES OF SELECTED SITES

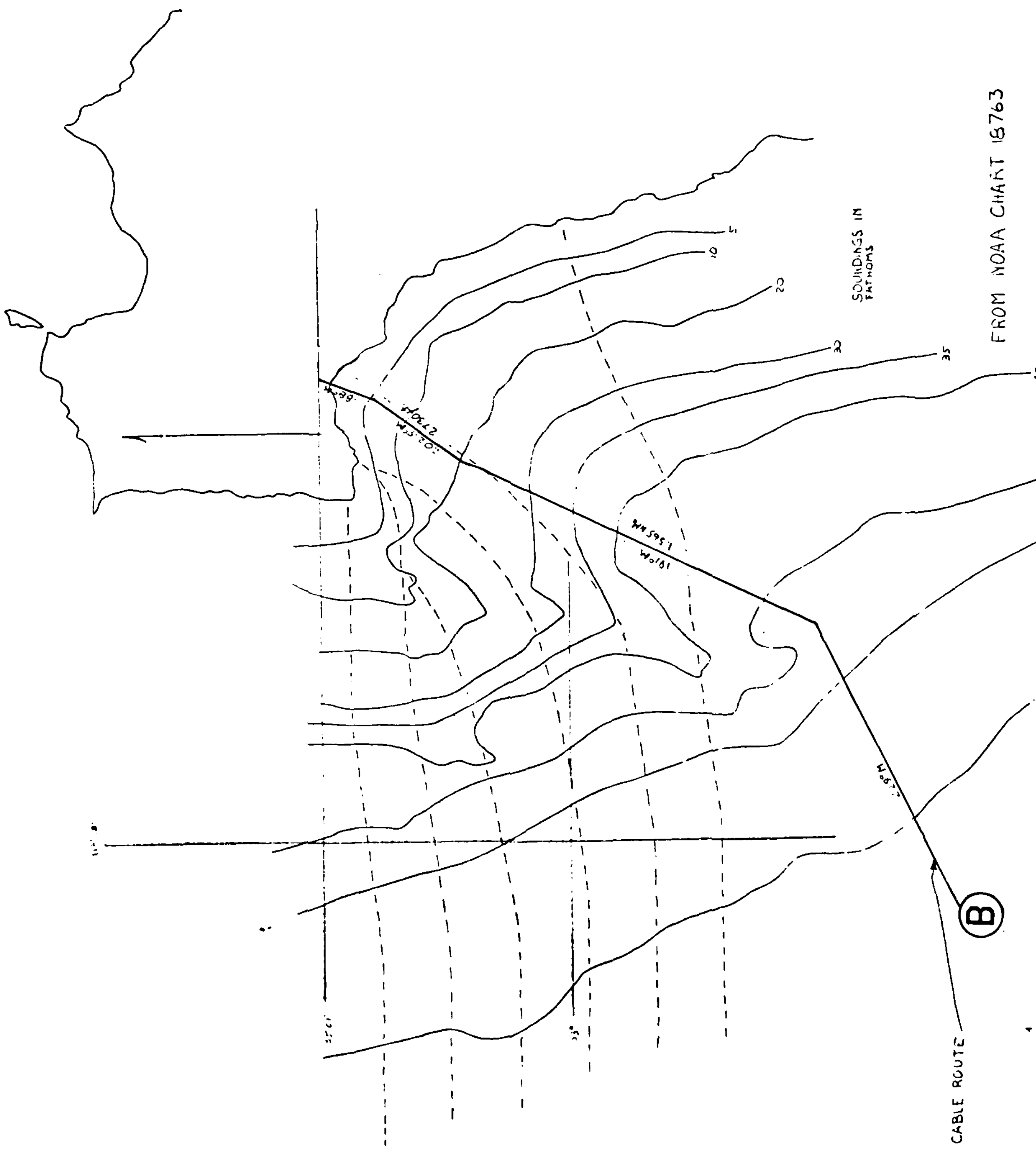


FIGURE 9. WEST COVE CABLE ROUTE

CHESAPEAKE DIVISION **Naval Facilities Engineering Command NDW** **DISCIPLINE**	**PROJECT:** SAR **Station:** SAN CLEMENTE IS. **E S R:** ______ **Contract:** ______
Calcs made by: W. SEELIG **date:** 5/19/84 **Calcs ck'd by:** ______ **date:** ______	**Calculations for:** CABLE STABILITY CABLE ON ROCK

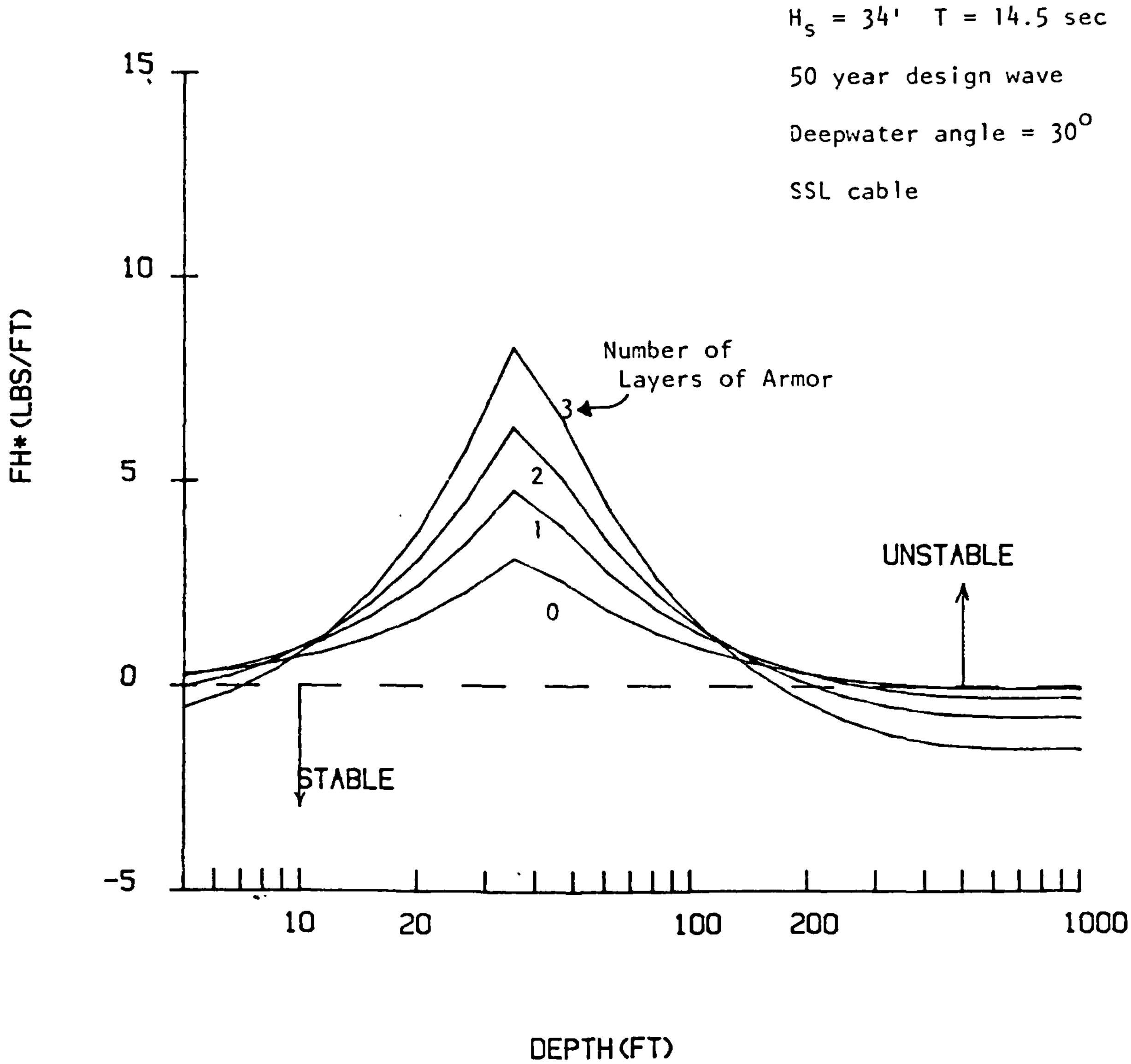


FIGURE 10. STABILITY OF AN SSL CABLE ON ROCK

page ___ **of** ___

GPO 888-693

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: ____________ Station: ____________
Calcs made by: __________ date: ______ Calcs ck'd by: __________ date: ______	E S R: ________ Contract: ________ Calculations for: ____________

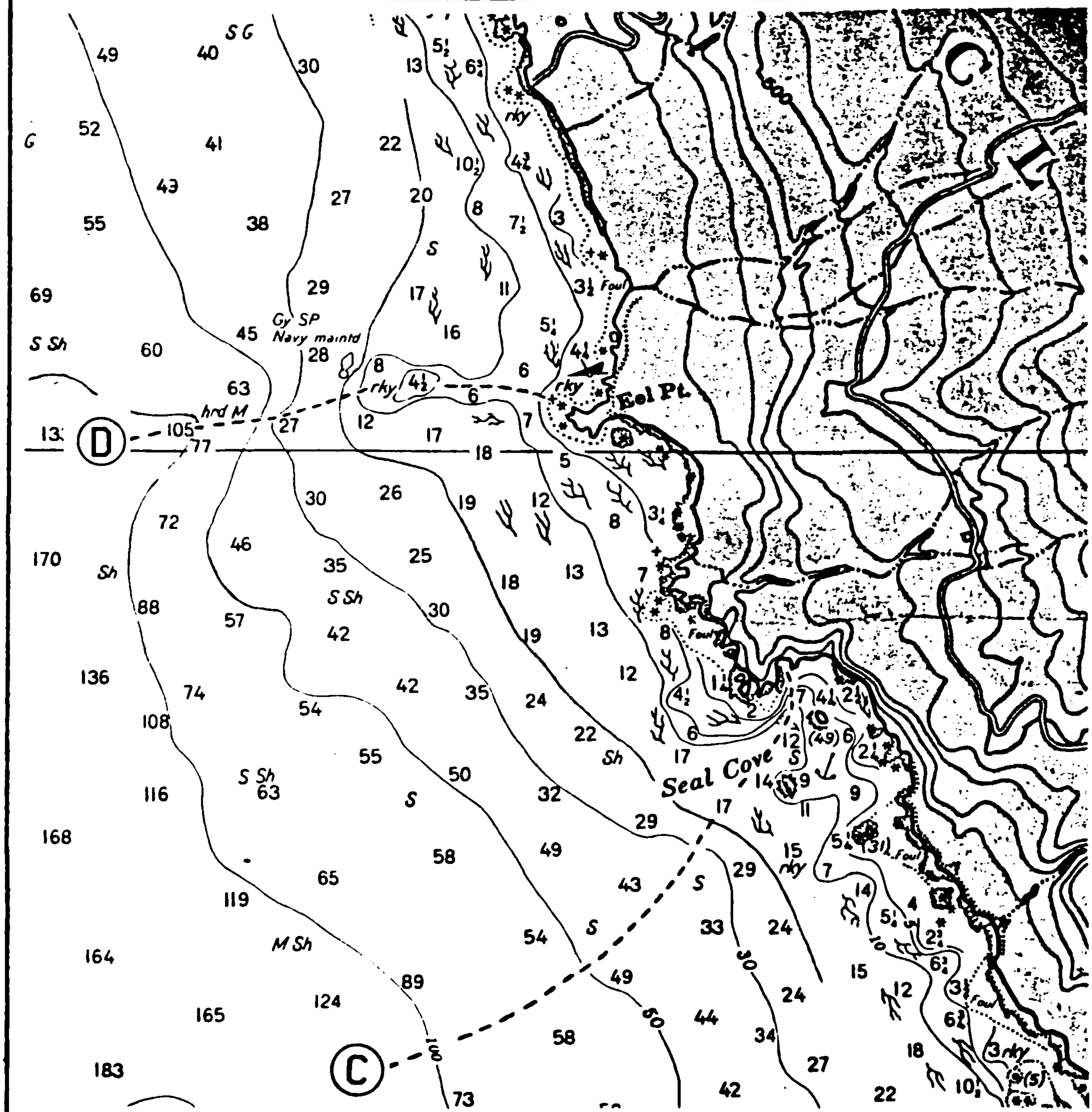


FIGURE 11. POSSIBLE CABLE ROUTES AT SEAL COVE AND EEL POINT

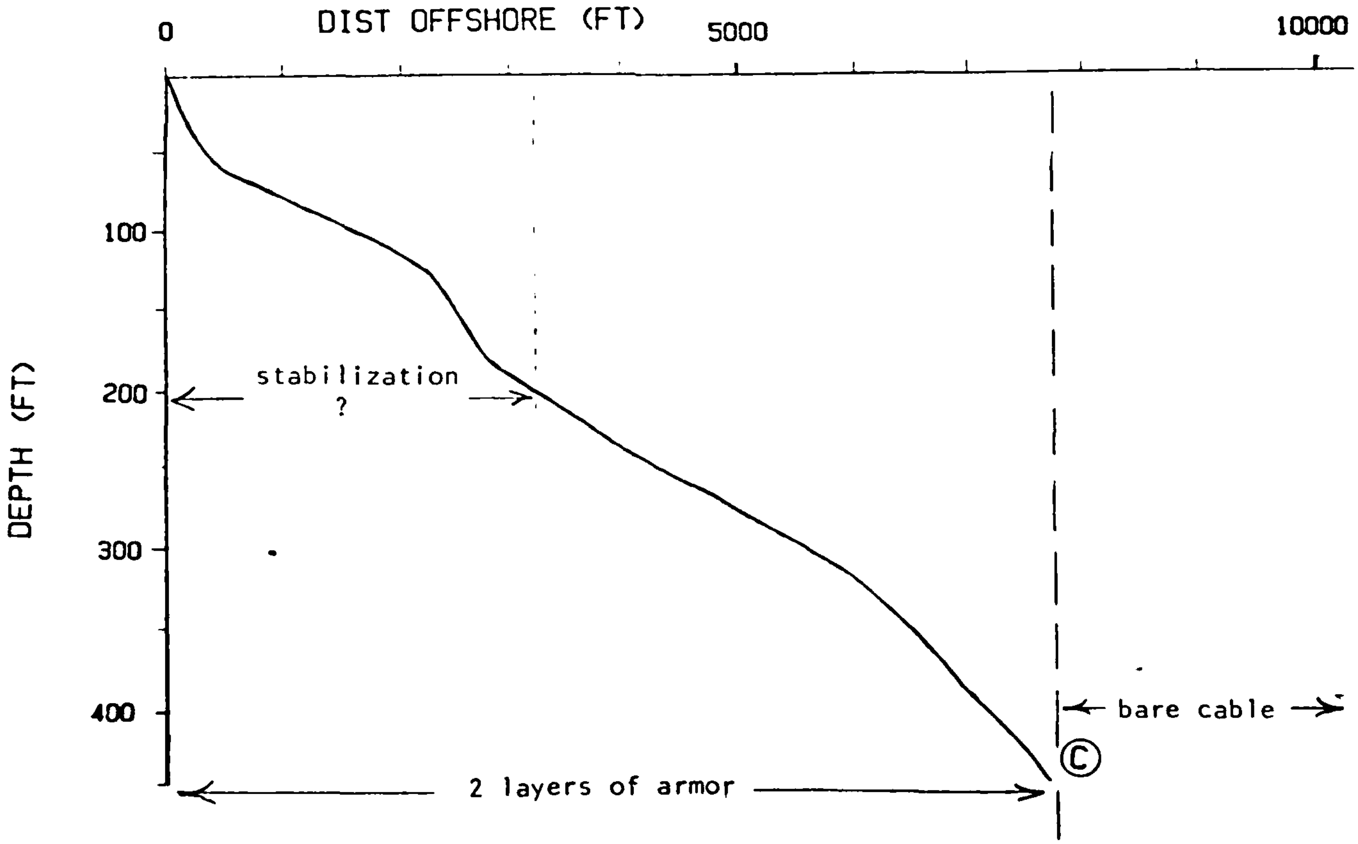
page ___ of ___

GPO 905-396

Nautical Miles

0 1 2

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: ____ Station: ____ E S R: ____ Contract: ____ Calculations for: ____
Calcs made by: ____ date: ____ Calcs ck'd by: ____ date: ____	

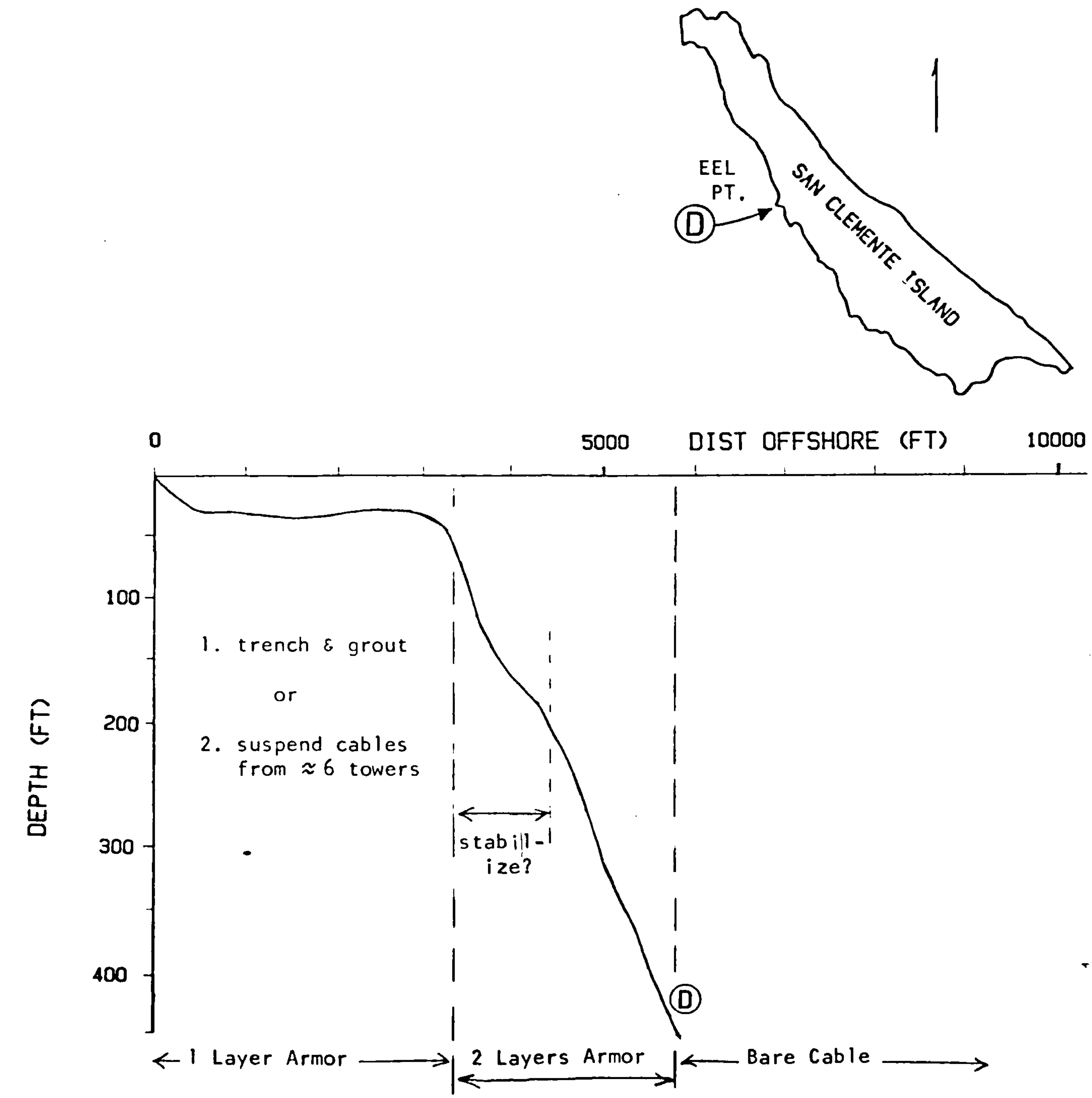


page ___ of ___

GPO 905-396

FIGURE 12. PROFILE AT SEAL COVE

CHESAPEAKE DIVISION Naval Facilities Engineering Command NDW DISCIPLINE	PROJECT: SAR Station: SAN CLEMENTE - EEL PT. E S R: ______ Contract: ______
Calcs made by: ______ date: ______ Calcs ck'd by: ______ date: ______	Calculations for: ______



page ___ of ___

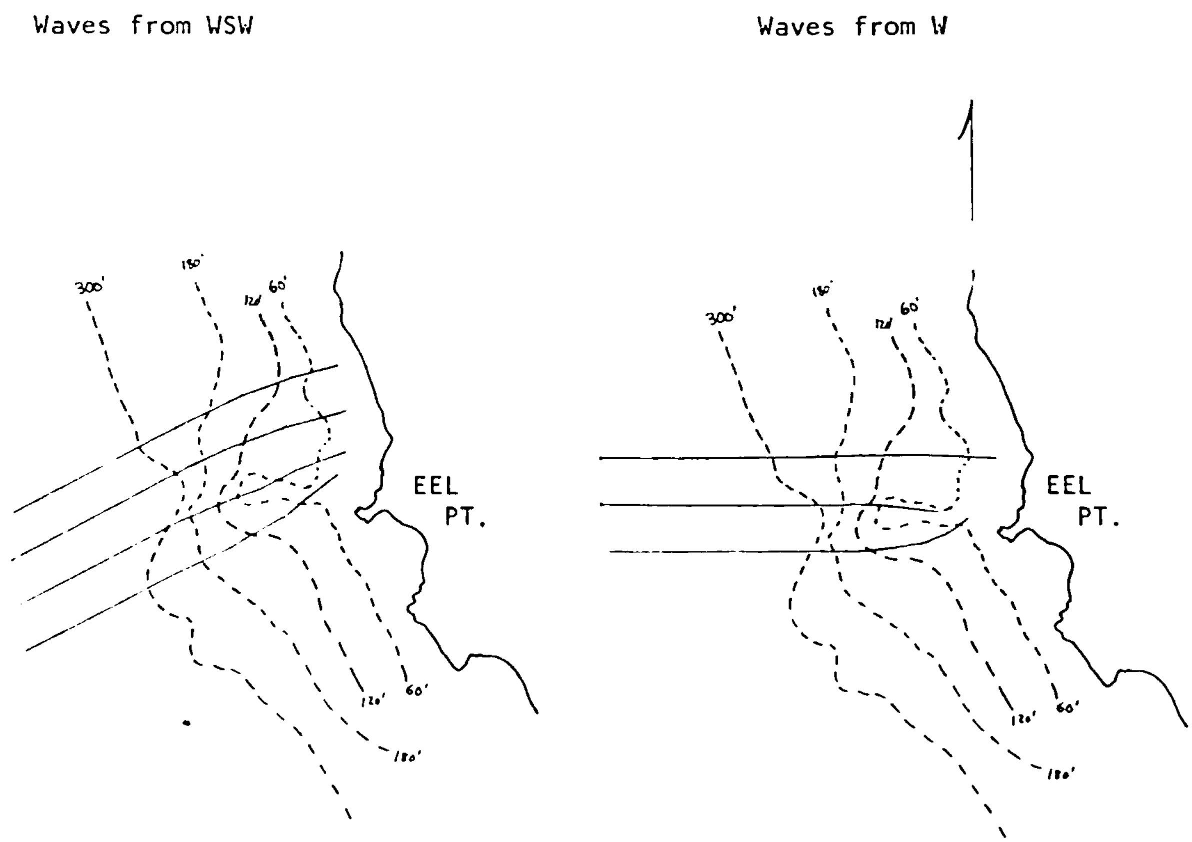
GPO 905-396

FIGURE 13. PROFILE AT EEL POINT

CHESAPEAKE DIVISION **Naval Facilities Engineering Command NDW** **DISCIPLINE**	**PROJECT:** SAR **Station:** SAN CLEMENTE - EEL POINT **E S R:** ____ **Contract:** ____
Calcs made by: W. SEELIG **date:** 5/18/84 **Calcs ck'd by:** ____ **date:** ____	**Calculations for:** Wave Refraction

Design Wave

T = 14.5 sec



page ___ of ___

GPO 888-883

FIGURE 14. WAVE REFRACTION AT EEL POINT

APPENDIX A. AVAILABLE DATA FOR DESIGNING CABLE LANDINGS AT SAN CLEMENTE ISLAND

The purpose of this appendix is to summarize data available for San Clemente Island that is useful in designing cable landings. Important references are cited and data are given.

WAVE DATA

Source	Description
Reference 3	SSMO ship board observations of waves
Reference 2	Wave data from Begg Rock for 1983
Table A-1 (this report)	Design waves for western San Clemente
Table A-2 (this report)	Design waves for eastern San Clemente
Table A-3 (this report)	Wave statistics for 1983 at Begg Rock

WIND DATA

Source	Description
Reference 4	Fastest mile design wind speeds
Table A-4 (this report)	Design mean hourly wind speeds from Ref 4 that have been analyzed using Ref 5

Table A-1. Design Waves for Western San Clemente Island (after Reference 8)

Return Interval (yrs.)	Design Wave Heights (ft.)	Period (sec.)
1	22	9
5	26	11.4
10	28	12.2
20	30	13.0
30	32	13.6
50	34	14.5
100	39	15.3

CHESAPEAKE DIVISION
Naval Facilities Engineering Command NDW
DISCIPLINE

PROJECT: SAR
Station: SAN CLEMENTE ISLAND
E S R: **Contract:**

Calcs made by: W. Seelig **date:** 5/20/84
Calcs ck'd by: **date:**

Calculations for: Table A-2. Design Waves for Eastern San Clemente Island

EASTERN SAN CLEMENTE ISLAND WAVE HINDCAST

AZIMUTH (DEG)	ANGLE (DEG)	FETCH (N.M.)					
			RETURN PERIOD(YRS)=	2.0	10.0	30.0	50.0
			WIND SPEED(KNTS)=	24.6	29.1	31.8	33.0
320.0	-85.0	77.0	H0 1/3(FT)=	8.0	9.5	10.4	10.8
			PERIOD(S) =	7.6	8.0	8.3	8.4
330.0	-75.0	77.0	H0 1/3(FT)=	8.0	9.5	10.4	10.8
			PERIOD(S) =	7.6	8.0	8.3	8.4
340.0	-65.0	68.0	H0 1/3(FT)=	7.5	8.9	9.7	10.1
			PERIOD(S) =	7.3	7.7	7.9	8.0
350.0	-55.0	60.0	H0 1/3(FT)=	7.1	8.4	9.1	9.5
			PERIOD(S) =	7.0	7.4	7.6	7.7
0.0	-45.0	25.0	H0 1/3(FT)=	4.6	5.4	5.9	6.1
			PERIOD(S) =	5.2	5.5	5.7	5.8
10.0	-35.0	25.0	H0 1/3(FT)=	4.6	5.4	5.9	6.1
			PERIOD(S) =	5.2	5.5	5.7	5.8
20.0	-25.0	18.0	H0 1/3(FT)=	3.9	4.6	5.0	5.2
			PERIOD(S) =	4.7	4.9	5.1	5.2
30.0	-15.0	20.0	H0 1/3(FT)=	4.1	4.8	5.3	5.5
			PERIOD(S) =	4.8	5.1	5.3	5.3
40.0	-5.0	48.0	H0 1/3(FT)=	6.3	7.5	8.2	8.5
			PERIOD(S) =	6.5	6.9	7.1	7.2
50.0	5.0	49.0	H0 1/3(FT)=	6.4	7.6	8.3	8.6
			PERIOD(S) =	6.5	6.9	7.1	7.2
60.0	15.0	51.0	H0 1/3(FT)=	6.5	7.7	8.4	8.8
			PERIOD(S) =	6.6	7.0	7.2	7.3
70.0	25.0	56.0	H0 1/3(FT)=	6.8	8.1	8.8	9.2
			PERIOD(S) =	6.8	7.2	7.4	7.5
80.0	35.0	60.0	H0 1/3(FT)=	7.1	8.4	9.1	9.5
			PERIOD(S) =	7.0	7.4	7.6	7.7
90.0	45.0	64.0	H0 1/3(FT)=	7.3	8.6	9.4	9.8
			PERIOD(S) =	7.1	7.6	7.8	7.9
100.0	55.0	67.0	H0 1/3(FT)=	7.5	8.8	9.7	10.0
			PERIOD(S) =	7.3	7.7	7.9	8.0
110.0	65.0	77.0	H0 1/3(FT)=	8.0	9.5	10.4	10.8
			PERIOD(S) =	7.6	8.0	8.3	8.4
120.0	75.0	83.0	H0 1/3(FT)=	8.3	9.8	10.8	11.2
			PERIOD(S) =	7.8	8.2	8.5	8.6
130.0	85.0	90.0	H0 1/3(FT)=	8.7	10.3	11.2	11.6
			PERIOD(S) =	8.0	8.5	8.7	8.8

Table A-3. Wave Statistics for Western San Clemente Island for 1983 (after Reference 2)

BEGG ROCK BUOY JAN-DEC 1983

JOINT DISTRIBUTION TABLE

TOTAL OBSERVATIONS = 1323

SIGNIFICANT WAVE HEIGHT (CM.) vs. PEAK PERIOD (SEC)

SIGNIFICANT WAVE HEIGHT (CM.)	22+	20	17	15	13	11	9	7	5
900									
870									
840									
810									
780									
750		1							
720									
690									
660									
630		1							
600									
570			2						
540		1	1		1				
510		1	3						
480		2	3	2		1			
450		1	3	2	2	1	2	1	
420		1	1	8	2		1	2	
390		2	3	8	9	1	6	4	
360		1	8	8	7	6	5	6	
330		1	3	12	12	9	6	5	1
300	1	3	3	10	20	13	9	16	2
270		3	8	11	20	18	12	25	4
240			3	11	19	16	21	35	12
210		3	3	7	16	26	24	51	27
180			7	11	16	24	42	54	42
150		1	14	9	39	42	50	38	64
120			8	5	24	25	29	26	72
90		1	1	11	5	8	11	4	15
60								1	2
30									

PEAK PERIOD (SEC)

Table A-4. Average Hourly Design Wind Speeds for San Clemente Island (from References 4 and 5)

Return Period (years)	Average Hourly Wind Speed (knots)
2	24.6
10	29.1
30	31.8
50	33.0

MAP/CHART DATA

Source	Description
NOAA Chart 18762(1982)	"San Clemente Island" showing the entire island at a scale of 1:40,000
NOAA Chart 18763(1981)	"San Clemente Island, Northern Part" showing the northern half at 1:20,000
NOAA Chart 18740(1982)	"San Diego to Santa Rosa Island" showing the entire area offshore of southern California at a scale of 1:234,270
DMA Chart 18741(1983)	"Fleet Operating Areas Southern California" scale of 1:234,270
USGS (1943/1980)	"San Clemente Island, North, Calif." scale of 1:24,000
"	"San Clemente Island, Central, Calif."
"	"San Clemente Island, South, Calif."

SURVEY DATA

Source	Description
NOAA National Ocean Survey* (Rockville, Md.)	Numerous surveys in the area of San Clemente Island have been made. The extent, scale and ID code of each survey are given in Tables A-5 and A-6. Selected surveys have been ordered as a part of this study.
Reference 7	A brief study of West Cove
Reference 12	A deepwater survey of the range site off of West Cove

*NOTE: NOAA NOS survey data can be viewed on microfilm in Rockville or ordered for $22.50 each (POC: George Mastrogianis 443-8408)

Table A-5. Old Survey Data (NOAA)

Hydrographic Surveys

Number	Hydrographer	Scale	Date
5235	O.W. Swainson	10,000	1933
5304	R.W. Knox	40,000	1933
5332	" " "	20,000	1932
5363	" " "	10,000	1933
5364	" " "	10,000	1933
5390	" " "	10,000	1933
5391	" " "	10,000	1933
5392	" " "	10,000	1933
5396	" " "	10,000	1933
5397	" " "	10,000	1933
5404	" " "	5,000	1934
5429	" " "	5,000	1934
5459	" " "	10,000	1933
5474	" " "	20,000	1933
5475	" " "	20,000	1933
5485	" " "	10,000	1933
5486	" " "	10,000	1933-34
5486 Ad.Wk	" " "	5,000 10,000	1935
5487	" " "	10,000	1933-34

Number	Hydrographer	Scale	Date
5680	R.W. Knox	10,000	1934
5680a	" " "	10,000	1934
5758	O.W. Swainson	20,000	1933-34
[illegible] Ad.Wk	R.P. Moore	20,000	1935
5775	O.W. Swainson	120,000	1933
5848	" " "	40,000	1934
5851	" " "	80,000	1934-35
6115	" " "	40,000	1934-35
6116	" " "	40,000	1935
6117	" " "	40,000	1935
6118	" " "	80,000	1935
6118 Ad.Wk.	H.B. Campbell	120,000	1937
6119	O.W. Swainson	80,000	1935
6119 Ad.Wk	H.B. Campbell	120,000	1937
6120	O.W. Swainson	80,000	1935
6121	" " "	120,000	1935
6128	H.B. Campbell	5,000	1936
[illegible]	" " "	[illegible]	1936
6165 WD	F.H. Hardy	10,000	1936
[illegible] WD	" " "	[illegible]	1936
[illegible] WD	" " "	[illegible]	1936
6186 WD	" " "	20,000	1936
6187 WD	" " "	20,000	1936
6206	H.B. Campbell	40,000	1936
6207	" " "	20,000	1936
6208	" " "	80,000	1936
6211	" " "	80,000	1936
6258	" " "	80,000	1937
6259	" " "	80,000	1937
6260	" " "	80,000	1937
6261	" " "	20,000	1937
6986	W.W. Grabill	[illegible]	1944

Number	Hydrographer	Scale	Date
5507	O.W. Swainson	40,000	1933-34
552[illegible]	R.W. Knox	20,000	1933-34
5524	" " "	20,000	1934
5532	" " "	10,000	1934
5533	" " "	10,000	1934
[illegible] Ad.Wk.	O.W. Swainson	10,000	1935
5534	R.W. Knox	10,000	1934
5555	" " "	20,000	1934
5556	" " "	10,000	1934
5557	" " "	5,000	1934
5558	" " "	5,000	1934
5600	O.W. Swainson	20,000	1933-34
5601	" " "	20,000	1933
5601 Ad.Wk.	H.B. Campbell	20,000	1937
5602	R.W. Knox	10,000	1934
5603	" " "	10,000	1934
5604	" " "	10,000	1934
5605	" " "	10,000	1934
5606	" " "	10,000	1934
5645	O.W. Swainson	40,000	1934
5646	" " "	40,000	1932-33
5648	R.W. Knox	10,000	1934
5649	" " "	10,000	1934
5653	O.W. Swainson	40,000	1933-34
[illegible]53 Ad.Wk.	" " "	40,000	1935
5658	R.W. Knox	20,000	1934
5663	" " "	10,000	1934
5664	" " "	10,000	1934
5665	" " "	10,000	1934
5666	" " "	10,000	1934
5676	" " "	10,000	1934
5677	" " "	10,000	1934
5678	" " "	20,000	1934
5679	" " "	10,000	1934

Number	Hydrographer	Scale	Date
FE No. 1 1954	C.A. George	20,000	1954
6209	H.B. Campbell	200,000	1936
[illegible]35	C.A. George	10,000	1954
8920	G.L. Short, R.E. Moses	10,000	1967-70
8980	K.W. Jeffers	40,000	1968
8979	" " "	20,000	1968
9105	R.E. Moses	10,000	1970
9106	" " "	10,000	1970
9107	" " "	10,000	1970
8978	K.W. Jeffers	10,000	1968
8921	" " "	10,000	1968
9113	D.R. Tibbit	40,000	1970
9114	" " "	40,000	1970
9111	" " "	40,000	1970
9112	" " "	40,000	1970
9108	R.E. Moses	40,000	1970
9065	E.A. Taylor	40,000	1969

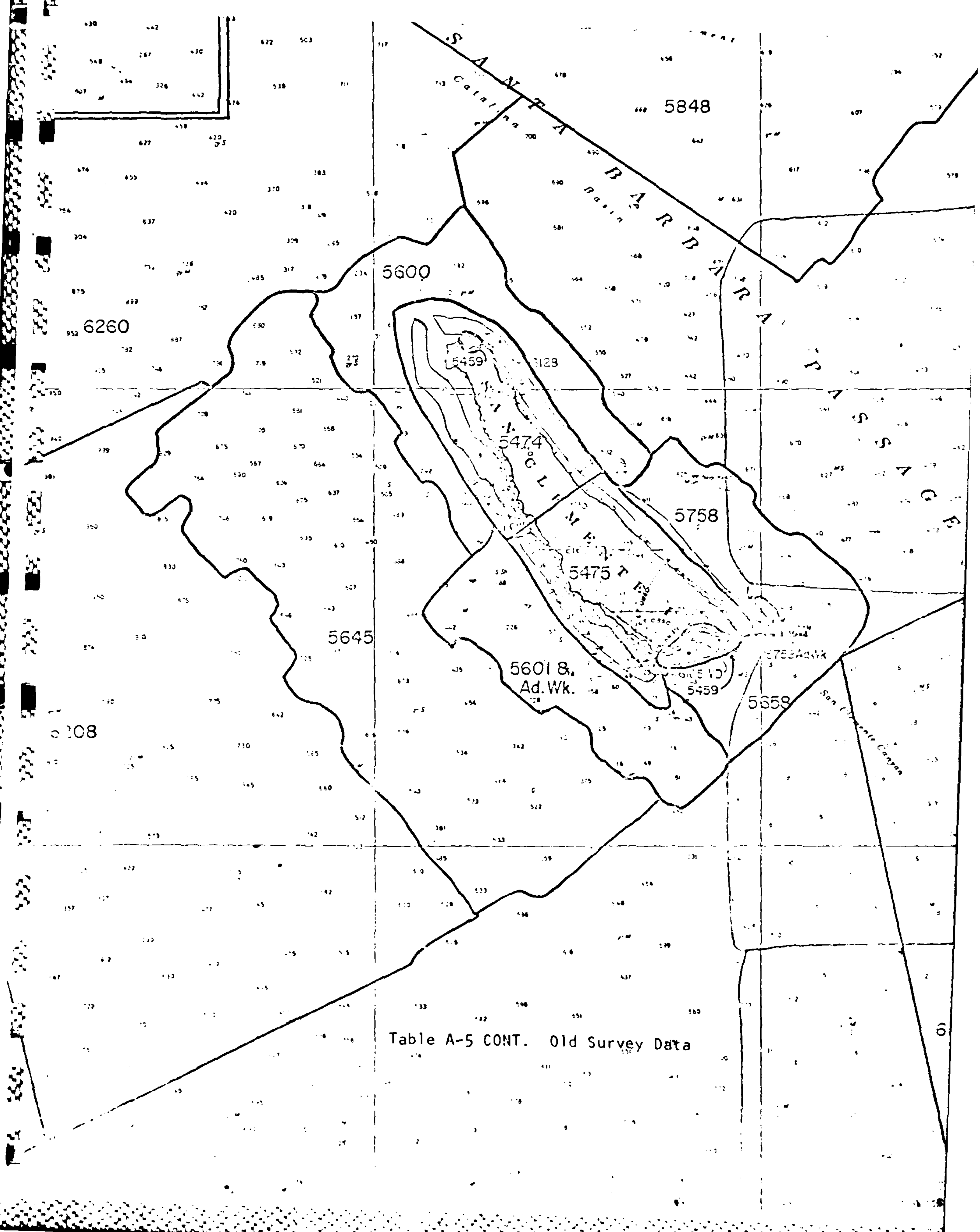


Table A-5 CONT. Old Survey Data

Table A-6. New NOAA Survey Data

Hydrographic Surveys

Number	Hydrographer	Scale	Date
9067-68	E.A.Taylor	80,000	1969
9244-45	R.F.Lanier	5,000	1971
9246	" " "	10,000	1971
9248-49	" " "	10,000	1971
9250-51	" " "	10,000	1971
9252	" " " & G.E.Haraden	10,000	1971-'72
9253	" " "	40,000	1971-'72
9274	G.E.Haraden	5,000	1972
9471	C.A.Burroughs	5,000	1974
9508	R.E. Alderman	20,000	1975
9275	G.E.Haraden	10,000	1972
9496	C.K.Townsend	5,000	1975
9468	C.A.Burroughs	10,000	1974
9469	" " "	10,000	1974
9580	C.K.Townsend	10,000	1975
9576	R.E.Alderman	20,000	1976
9559	" " "	10,000	1975
9498	C.K.Townsend	20,000	1975
9575	R.E.Alderman	10,000	1975
9560	" " "	10,000	1975
9499	C.K.Townsend	20,000	1975

Number	Hydrographer	Scale	Date
9561	R.E.Alderman	20,000	1975
9467	C.A.Burroughs	10,000	1974
9558	R.E.Alderman	10,000	1975
9470	C.A.Burroughs	5,000	1974
9493	R.E.Alderman	10,000	1975
9598	" " "	10,000	1975
9487	" " " & C. Burroughs	10,000	1974-75
9591	R.E.Alderman	20,000	1976
9592	" " "	5,000	1976
9276	G.E.Haraden	10,000	1972
9662	J.P.Randall	20,000	1976
9600	R.E.Alderman	10,000	1976
9495	" " "	5,000	1975
9247	K.W. Jeffers, R.F. Lanier, & G.E. Haraden	10,000	1971,'73,'74
9494	R.E. Alderman	20,000	1975
9254	R.F. Lanier G.E. Haraden & K.W. Jeffers	80,000	1971,'73,'74
9277	G.E.Haraden	40,000	1972
9492	R.E.Alderman	10,000	1975
9497	C.K.Townsend	5,000	1975
9664	J.P.Randall	5,000	1976
9667	J.P. Randall	20,000	1976
9570	C.K. Townsend	5,000	1975
9672 Ba	R.E. Alderman & B.L.Williams	5,000	1977-'78
9673	" " " " " "	5,000	1977
9674	" " " " " "	5,000	1977
9590	" " " " " "	10,000	1976-'77
9376	G.E. Haraden & K.W. Jeffers	20,000	1973-'74
9377	" " " " " "	20,000	1973-'74
9599	R.E. Alderman & B.L.Williams	10,000	1976-'77
9725	J.P. Randall	20,000	1977
9670	R.E.Alderman & B.L.Williams	5,000	1977-'78
9728	J.P.Randall	20,000	1977
9467	K.W. Jeffers	5,000	1974

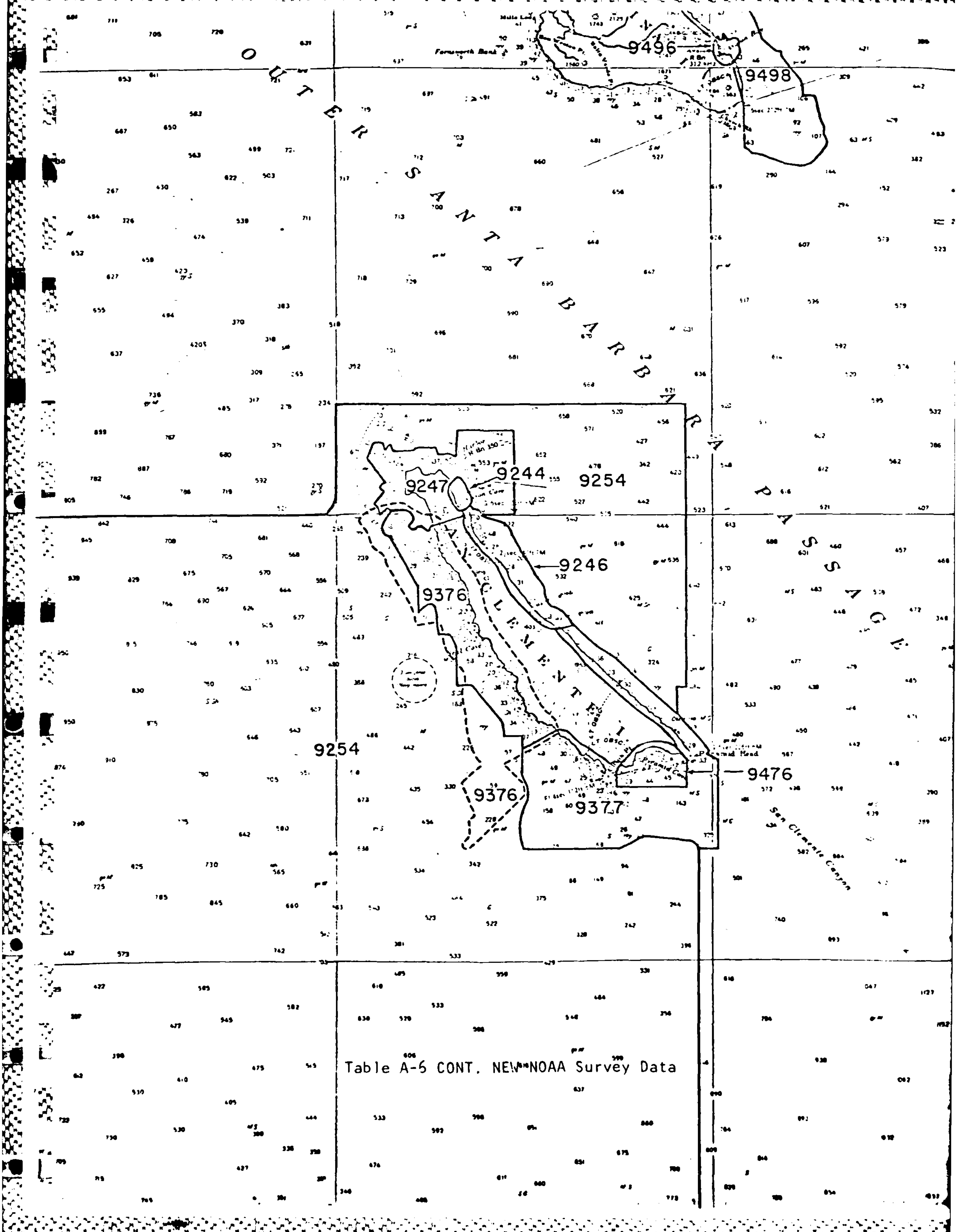
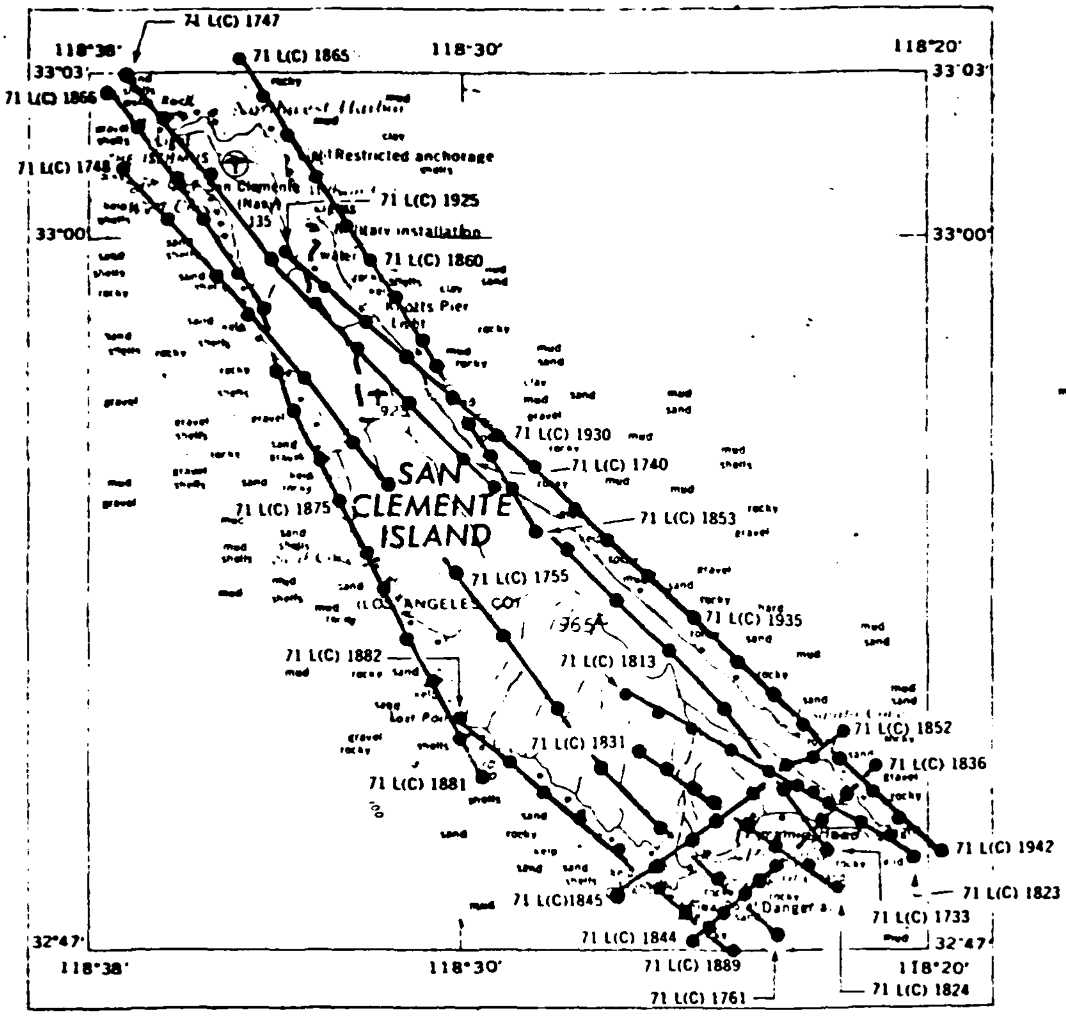


Table A-6 CONT. NEW NOAA Survey Data

AERIAL PHOTOS

Numerous aerial photos are available for San Clemente Island. For example, Table A-7 shows flight lines and lists of photos available from the National Ocean Survey Rockville Md. The US Geological Survey also has an excellent microfilm photo library where photos from a wide variety of sources can be viewed and ordered. Selected NASA photos in this library have been ordered as a part of this study.

Table A-7. National Ocean Survey Photo Flight Lines



ROLL NO	PHOTO NO'S	SCALE	DATE
100-633	71 L(C) 1466-1484	1:20,000	3-5-71
100-633	71 L(C) 1568-1573	1:15,000	3-5-71
100-634	71 L(C) 1605-1606	1:15,000	3-5-71
100-634	71 L(C) 1621-1640	1:18,000	3-5-71
100-634	71 L(C) 1670-1678	1:30,000	3-5-71
100-635	71 L(C) 1733-1761	1:30,000	3-6-71
100-635	71 L(C) 1813-1831	1:15,000	3-6-71
100-635	71 L(C) 1836-1852	1:15,000	3-6-71
100-635	71 L(C) 1853-1889	1:20,000	3-6-71
100-636	71 L(C) 1925-1942	1:20,000	3-6-71
100-734	72 L(C) 2260-2279	1:30,000	3-23-72
100-734	72 L(C) 2283-2289	1:30,000	3-23-72
100-734	72 L(C) 2290-2321	1:15,000	3-23-72
100-734	72 L(C) 2395-2399	1:15,000	3-23-72
100-735	72 L(C) 2592-2600	1:30,000	3-23-72
100-735	72 L(C) 2666-2707	1:30,000	3-23-72
100-736	72 L(C) 2713-2761	1:30,000	3-24-72
100-736	72 L(C) 2875-2932	1:15,000	3-24-72
100-741	72 L(C) 3017-3044	1:15,000	3-27-72
100-741	72 L(C) 3050-3072	1:15,000	3-27-72

AIR PHOTO INDEX 66-A

DATE OF INDEX 1/1/73

GEOLOGIC DATA

Much information is available on the geology of San Clemente Island, including seismic maps, gelogic maps, etc. from the US Geologic Survey, Reston, Virginia. Point of Contact at the USGS is Jeff Williams at 860-6431 or 860-7468.

APPENDIX B. FORCES ON CABLES AND STABILITY

OF CABLES ON ROCK

If a cable is resting on a rock or a hard bottom then waves and currents will produce forces on the cable. Waves cause special problems if the reversing currents cause the cable to move and produce abrasion against the rock.

Reference (1) gives a detailed description of forces on cables. These forces are: the weight of the cable holding it down, lift forces pulling it up, drag forces pulling from side to side and a coefficient of friction, μ, between the cable and the bottom resisting cable motion. These forces are shown in Figure B-1. The coefficient of friction typically has a value of $\mu = 0.3$ and detailed calculation procedures are given in Reference (1). Examples of these calculations are given below.

EXAMPLE 1 - A STEADY CURRENT ACTING ON A CABLE

GIVEN : Cables with the following characteristics:

Number of Passes of Armor	Dia (ft)	Wt (lbs/ft)	W/D
SSL 1 pass	0.08817	0.9128	10.4
SSL 2 passes	0.1235	2.4804	20.0

FIND: The currents for which the cables are stable assuming the current is normal to the cable.

SOLUTION: Using techniques in Reference (1) it is found that the cable with one pass of armor is stable on rock for currents up to 1.86 ft/sec and with two passes up to 2.59 ft/sec. Therefore the cable with the greater weight to diameter ratio is more stable.

EXAMPLE 2 - FORCES ON AN UNSTABLE CABLE

GIVEN: The same cables as in Example 1.

FIND: What is the net force, F_H^* , on the cables when they are unstable with a current of 5 ft/sec?

SOLUTION: Using methods of Reference (1) it is found that the net force is 1.7 lbs/ft for cable with one pass of armor and 2.5 lbs/ft for the cable with two passes of armor. Therefore, the cable with a greater weight to diameter ratio is more stable than a lighter cable for low velocities. However, in the unstable region there may be a point where the total net force is greater on the larger cable, even though the larger cable is relatively heavier.

EXAMPLE 3 - WAVE FORCES ON A CABLE

Wave forces on a cable are a complex function of the waves (wave height, direction, period, angle to the contours, angle to the bottom, refraction,

shoaling, breaking, etc.) as well as the properties of the cable. Therefore a computer program is used to make all the necessary calculations. Figure B-2 shows sample stability calculations for an SSL cable unarmored, with two passes of armor and with 5" split pipe. Cable is unstable for a 50 year design wave on Western San Clemente for the following conditions: Unarmored in 430 feet of water, with two passes of armor in 230 feet of water and with 5" split pipe in depths of 21 to 71 feet of water.

Figure B-3 shows the same calculations for a wave condition with a one year return interval. Table B-1 summarizes the predicted stability of cables on rock for the conditions examined. Cf course these conditions do not occur if the cables are buried in sand.

Note that it is generally not possible to make a cable exposed to large waves nearshore totally stable on rock without some tie down system. For example, a 0.1 foot diameter cable would have to weigh 13 lbs/ft in water to be stable for a wave with a one year return interval at Sam Clemente. Sheltering cables from larger waves or burying them in sand are two alternatives to tying them down.

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DISCIPLINE	E S R: Contract:
Calcs made by: date:	Calculations for:
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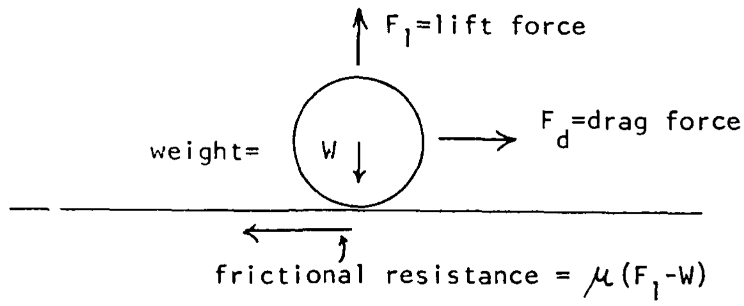

cable is stable if $F_H^* \leq 0$ where:

$$F_H^* = F_d + \mu(F_l - W)$$

Figure B-1. CABLE FORCES AND STABILITY

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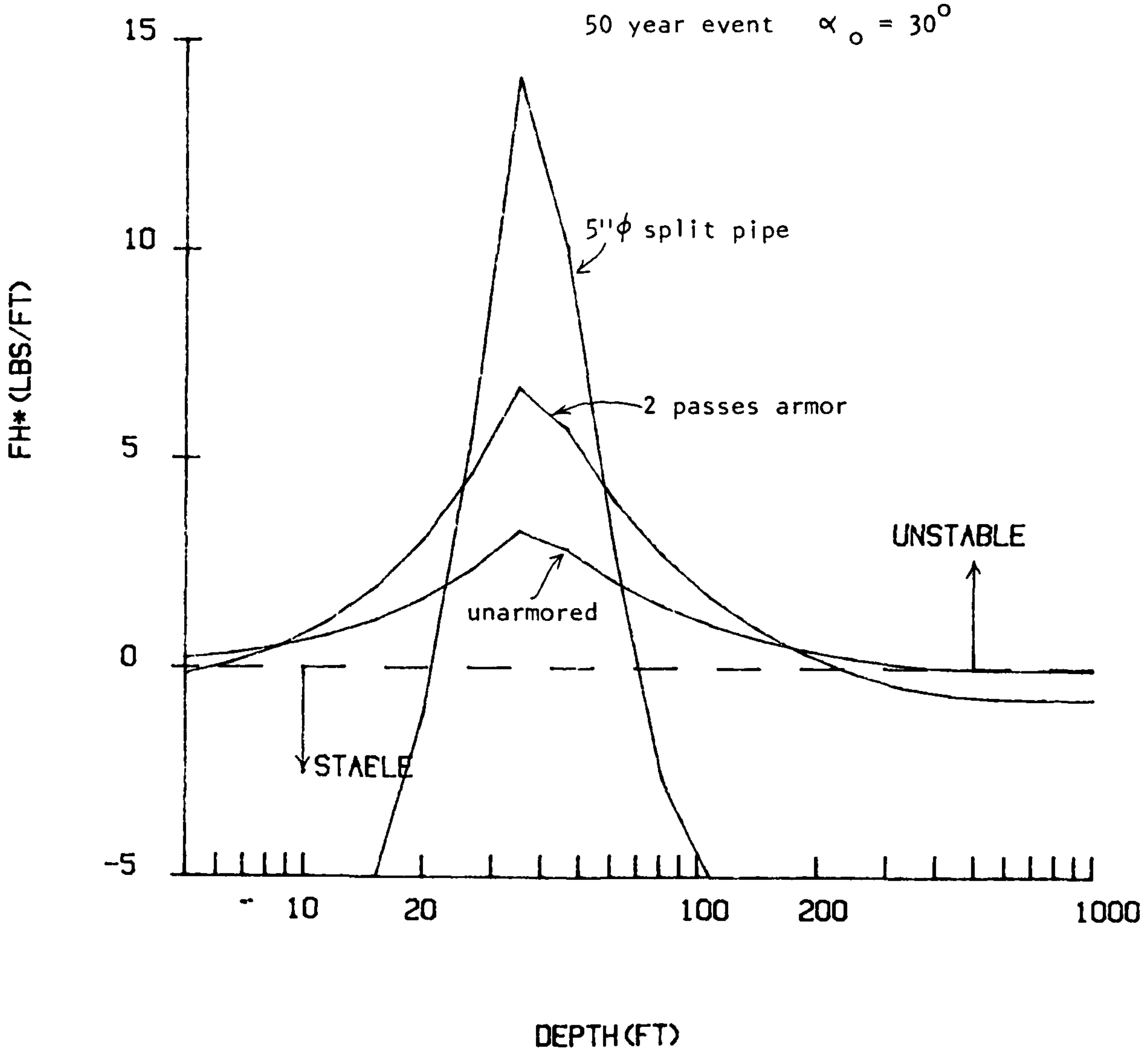
Figure B-2. SSL Cable Stability on Rock

50 year event $\alpha_o = 30^o$




```
M= .050 HO,H(FT)= 34.0 34.0 T(S)=14.5 WAVE ANG(D)=30.0
CABLE ANG(D)= 0.0 DIA(FT)=  .0550 WT(LBS/FT)=  .1557
CRITICAL DEPTH(FT) =   430.0
CABLE ANG(D)= 0.0 DIA(FT)=  .1235 WT(LBS/FT)= 2.4804
CRITICAL DEPTH(FT) =   230.5
CRITICAL DEPTH(FT) =     5.9
CABLE ANG(D)= 0.0 DIA(FT)=  .5208 WT(LBS/FT)=57.2000
CRITICAL DEPTH(FT) =    70.9
CRITICAL DEPTH(FT) =    21.1
```

Cable

2 Passes Armor

5" Split Pipe

PO 885-693

CHESAPEAKE DIVISION
Naval Facilities Engineering Command NDW
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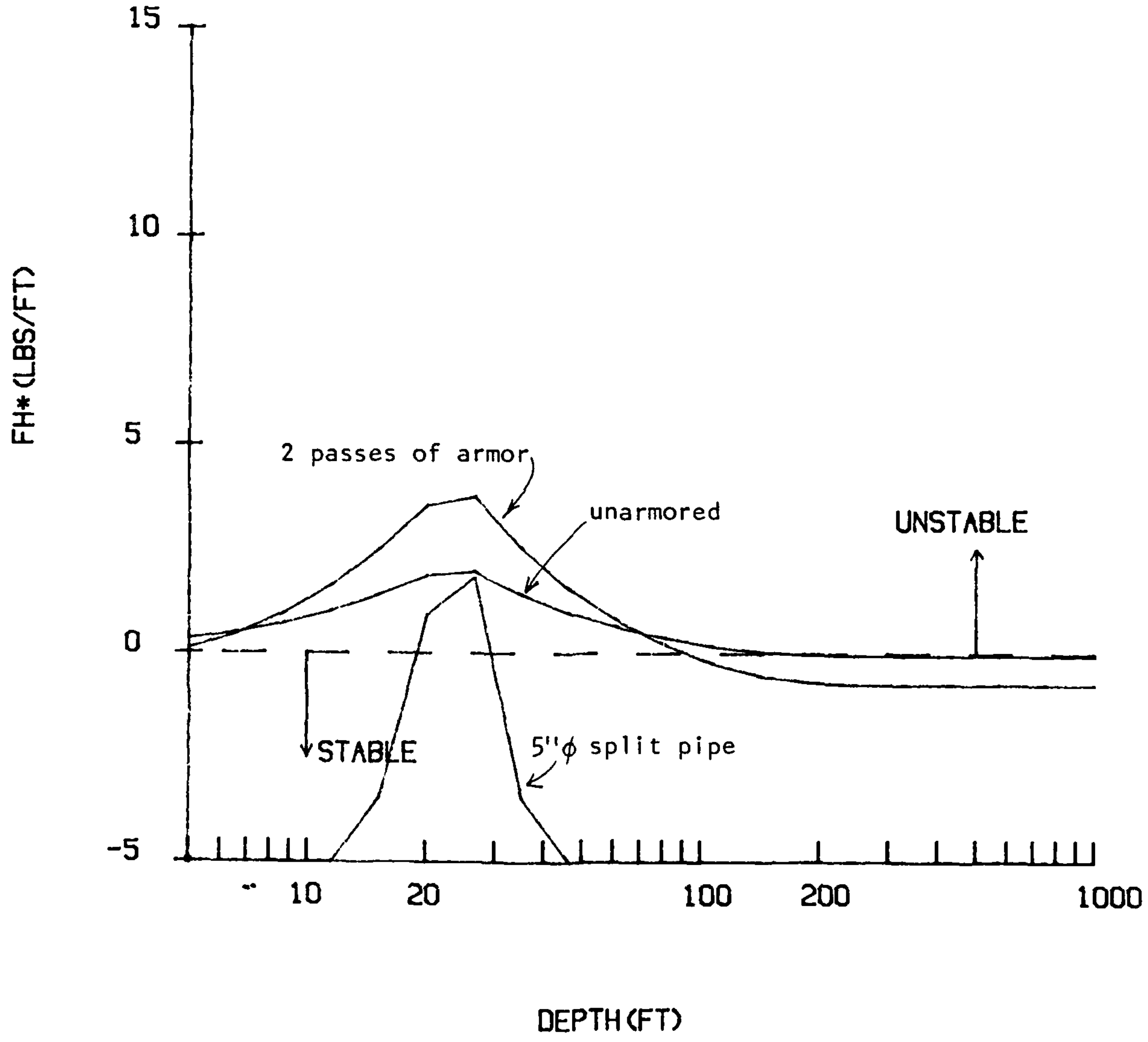
Station: ______
E S R: ______ **Contract:** ______

Calcs made by: ______ **date:** ______
Calcs ck'd by: ______ **date:** ______
Calculations for: ______

Figure B-3. SSL Cable Stability on Rock

1 year event $\alpha_o = 30^o$




```
M= .050 HO,H(FT)= 22.0 22.0 T(S)= 9.0 WAVE ANG(D)=30.0
CABLE ANG(D)= 0.0 DIA(FT)=  .0550 WT(LBS/FT)=  .1557   unarmored
CRITICAL DEPTH(FT) =   173.0
CABLE ANG(D)= 0.0 DIA(FT)=  .1235 WT(LBS/FT)= 2.4804   2 passes armor
CRITICAL DEPTH(FT) =    92.6
CABLE ANG(D)= 0.0 DIA(FT)=  .5208 WT(LBS/FT)=57.2000   5" split pipe
CRITICAL DEPTH(FT) =    29.3
 ?ITICAL DEPTH(FT) =    19.0
```

Table B-1. Predicted Range of Water Depths Where SSL Cables are Unstable on Rock (Western San Clemente Island).*

Range of Water Depths (ft)

Cable	Wave Return Interval (yrs)	
	1	50
Unarmored SSL	0'-173'	0'-430'
2 Passes Armor	0'-93'	6'-230'
5" Split Pipe	19'-29'	21'-71'

*Cables would have to be stabilized in these depths if rock is present.

APPENDIX C. PREDICTED BEACH AND OFFSHORE PROCESSES INFLUENCING CABLE LANDING DESIGN

A cable buried in sand is largely protected in the nearshore zone. The purpose of this appendix is to address how much sand is adequate.

If a beach and offshore profile is repeatedly surveyed an envelope of change is observed (Reference 10, Figure C-1). The shoreward end of the changes on the beach is approximately equal to the tide level plus wave runup height, R, (Point 1 on Figure C-1). The seaward limit of the active profile is given by d_{ℓ} (Reference 9). For water depths greater than d_{ℓ} the profile will generally change by one foot or less (Point 2 on Figure C-1). In water depths of less than d_{ℓ} large changes can be expected to the profile, or rock can be exposed if inadequate sediment is present. The maximum scour or profile change occurring during a long time interval (Point 3 on Figure C-1) is on the order of the design wave height occurring in the interval (Reference 10), if there is that much sand available. More typically, sand level changes are on the order of one-quarter to one-half of the wave height for areas of the profile between points one and two.

WAVE RUNUP PREDICTION

Wave runup, R, on a beach can be predicted by the equation, (Reference 6)

$$R = 2.26 \; m \; T\sqrt{H}$$

where m = beach slope

T = wave period in seconds

H = wave height in feet

Note that wave period and beach slope are more important in determining runup than the wave height.

For example,

GIVEN H = 22 feet

T = 9 seconds

m = 0.07

THEN

$$R = 2.26 \; (0.07) \; (9)\sqrt{22} \; = 6.7 \text{ feet}$$

PREDICTION OF THE ACTIVE PROFILE DEPTH, d_ℓ

The depth of water where one foot of sand level change occurs for a given wave period can be estimated from figure C-2. Using this diagram wave height is entered on the y-axis, d_ℓ is given on the x-axis and curves given for selected values of wave period (note that curves only extend to the breaking limit for a given wave period). For example, given a wave height of 20 feet and a period of 12 seconds, then d_ℓ = 40 feet. This means that sand level changes of greater than one foot would be expected in water depths of 40 feet or less.

Table C-1. Predicted Conditions at West Cove

Interval (years)	Design Wave Height (ft)	Wave Period (sec)	R (ft)*	R + Tide (ft)	d_ℓ (ft)
1	22	9	6.7	11.1	40
5	26	11.4	9.2	13.7	50
10	28	12.2	10.2	14.7	56
20	30	13.0	11.3	15.8	59
30	32	13.6	12.2	16.7	62
50	34	14.5	13.4	17.9	69
100	39	15.3	15.1	19.6	77

*m = 0.07
Note that higher runups will occur for longer period waves.

Predicted limits of the active profile limits are shown for West Cove in Table C-1 and presented graphically in Figure C-3. The extent of influence of wave events can be seen to expand over a greater range of depths and elevations as the event becomes more extreme.

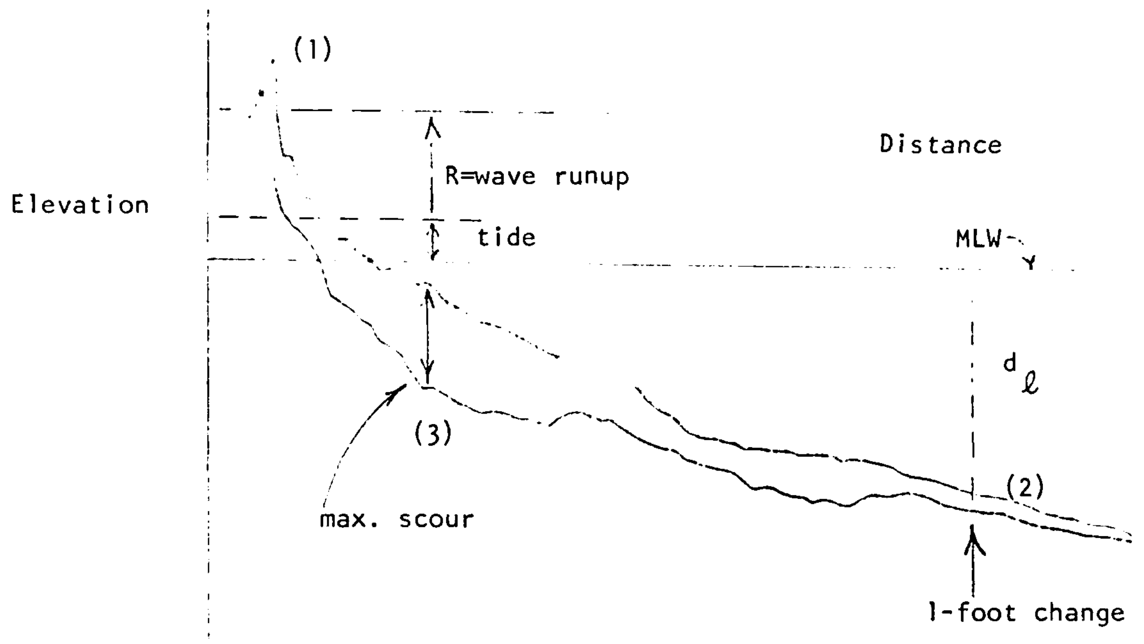
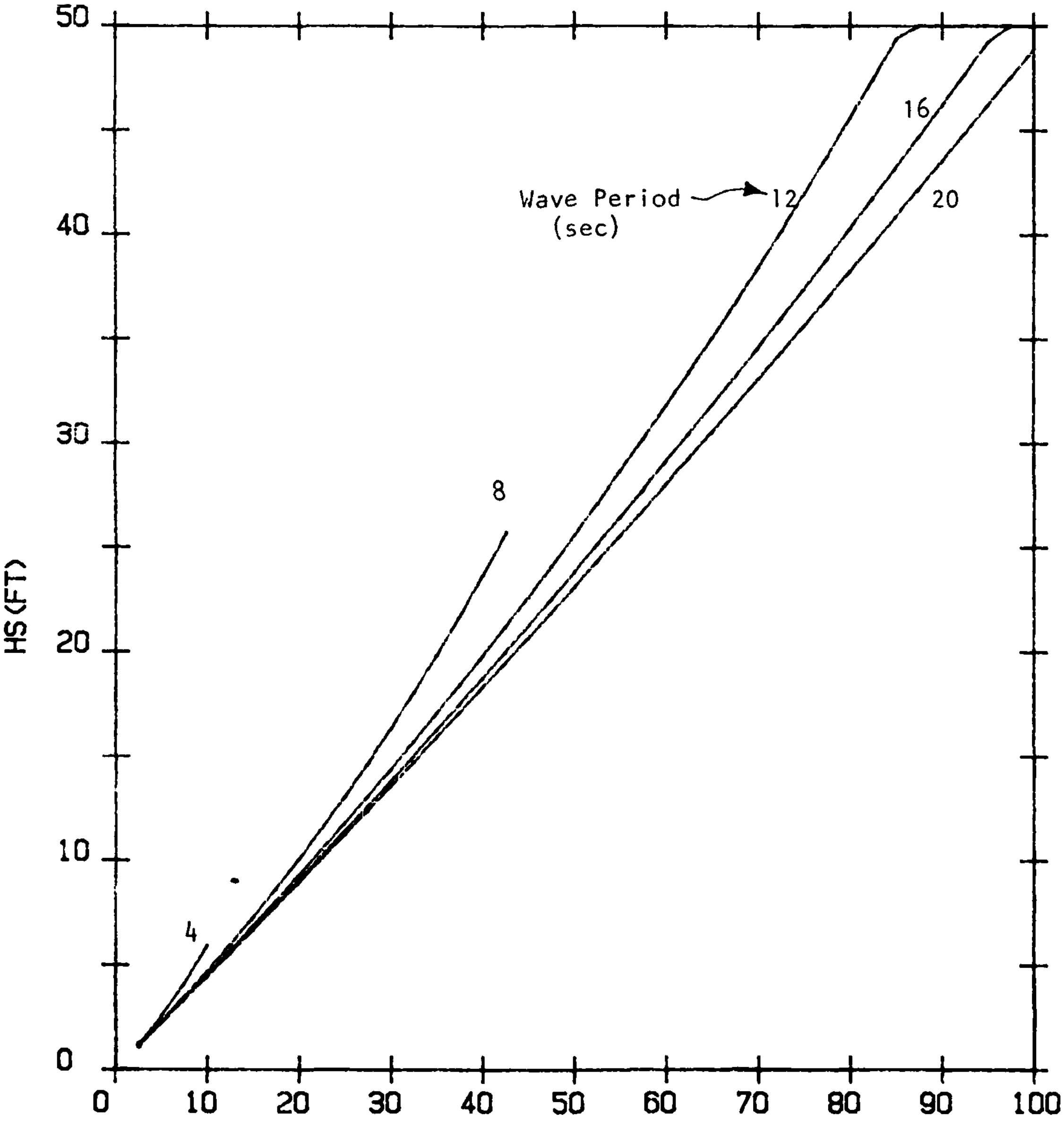


Figure C-1. ENVELOPE OF PROFILE CHANGES TYPICAL ON AND OFFSHORE OF A BEACH (after Reference 10)

CHESAPEAKE DIVISION	PROJECT:
Naval Facilities Engineering Command NDW	Station:
DISCIPLINE	E S R: Contract:
Calcs made by: W. Seelig date: 5/23/84	Calculations for: d_ℓ for Sand
Calcs ck'd by: date:	

(after Reference 9)

d_ℓ = depth of water where sand level change is predicted to be 1 foot



d_ℓ

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FIGURE C-2. Predicted Active Depth for Quartz Sand

GPO 905-396

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Calculations for: ______

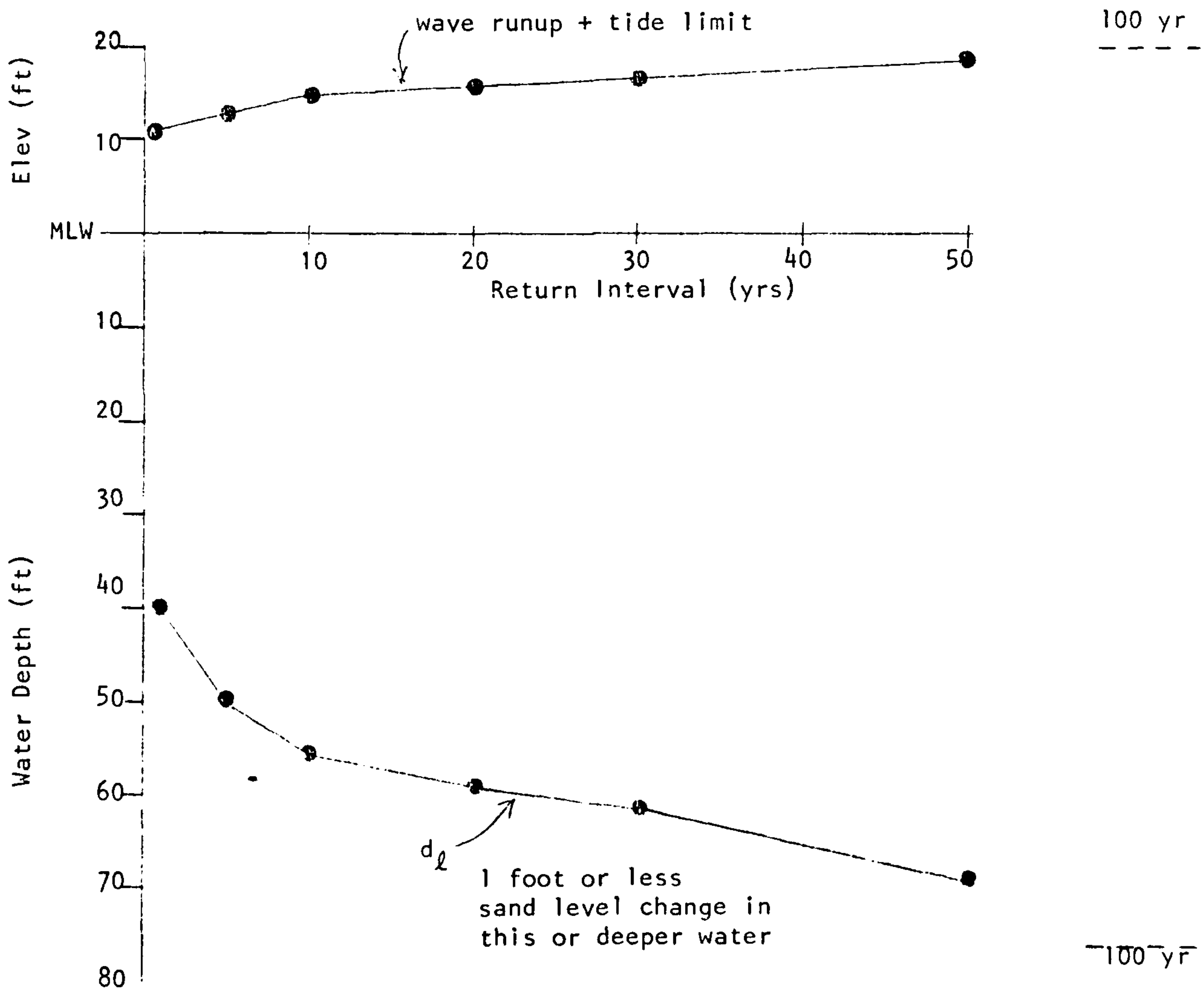

Figure C-3. Predicted Active Profile Limits for Western San Clemente Island as a Function of Return Interval

GPO 905-396

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